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of vigorous young plants in the tropics, but it is not always successful when the soil and temperature are not ideal. Under this circumstance, a new device for side-grafting in which immature wood is used is proposed by Ichizô Nakamura of Takao, Formosa. This device works very satisfactorily under tropical conditions in multiplying mango plants in a very speedy way. This new finding is described in the following paragraphs.

THEORETICAL STARTING POINT

In temperate countries where both budding and grafting are practiced the scion species used are mostly deciduous and the buds are dormant when cut, as those on immature wood are hard to revive. In tropical countries, in the case of the mango, the development of the bud does not require a long period of dormancy, and soft wood buds can be used for grafting purposes. Moreover, the healing of the wound is much easier when the plant is active in midsummer up to early fall when the temperature is high and the regenerative power is strong. In early spring the temperature is not high and the plant is more dormant than in summer and this gives a different effect to the plant. The root stock to be worked is also larger and more vigorous with the advance of the season and it is easy to force the bud to start strong growth. This supports the theory that spring is not the proper season when to practice grafting in the tropics, since the physiological and morphological conditions of the stock plant are, in summer rather than in spring, far more conducive to make the wound heal faster, force the inserted bud to grow easier, and complete the elongation of the shoot faster. It does not require an entire season to expect a full wood growth, as the growing season is long and the temperature favors a rapid elongation. Another important difference is the evaporation power. Ordinary scions used in the temperate countries in spring are dormant and keep a considerable length of time without losing their power of regeneration as the physiological activity is slow. Scions used in the tropics, on the other hand, are always active and ready to function even during winter, and are ever subject to lose water by transpiration and respiration. Under this condition, the scion must be properly protected against loss of water, and the budwood must be waterproof as far as possible. To answer this requirement, budwoods must have neither foliage nor petiole, and the leaf scar should be water-tight with complete cork formation after the natural abscission of the petiole. This can be attained by removing the leaf blade at the middle of the petiole, before the scion is cut, and by

waiting a week or so, the remaining petiole falls down with the formation of an abscission cork layer. Such wood is ready to be used as a scion. Without doing this, and if the leaves are removed at the time when the scion is cut, the cut surface of the petiole is likely to form a danger point, from which water may evaporate very quickly. Such scion will wither very rapidly and will not survive at all when used. Defoliation and healing of the leaf scar will unquestionably prevent the loss of water by the bud. Not only that. They accelerate the subsequent development of the bud into a sprout. The pre-curing of bud by defoliation renders the scion ready to start bud growth when used. This point is well explained in Mr. Nakamura's method and the factors which cause the failure of grafting in the tropics are wisely avoided and more logical processes substituted.

METHOD OF GRAFTING

In Mr. Nakamura's method, terminal or lateral buds, in an intermittent rest period between two cyclic growths, are to be used. If the terminal bud is wanted, several leaves from the top are removed, and the scion with two or three leaf scars is to be cut after the abscission of the petiole. The lower portion of the same stick can be used again, after two weeks or so, in the meantime waiting for the terminal cut to heal completely. After removing the leaf blade and the remaining petiole, the top part with several leaf scars, can be used as before for the scion. This time, the axillary buds in the uppermost position are to be developed. In a similar way, the still lower part of the same stick is available. It is better to remove all leaves of the entire shoot at the beginning, if several scions are to be obtained from the same shoot. (Plate 5, A, B, C).

The scion is inserted into the notch made on one side of the immature but fully developed root stock, while the bark is still green. Two- or three-year-old stocks with brown barks are also available but they are not so good as the green ones. Still larger stocks over two centimeters in diameter should be cut back when worked on with young sprouts. When the stock is old and top working is desired, the entire trunk is cut down in early spring at a point 15 to 18 cm. from the ground. From several adventitious sprouts arising near the cut surface, one or two opposite strong shoots may be saved, and such vigorous shoots are used when they grow big enough to work on. It does not matter how big the stock is, but the part to work on must not be fully mature

and dormant. When working on young plants, the stock is cut at a point 5 to 10 cm. from the ground, leaving two or three leaves, which are left untouched when the scion is inserted. (Plate 5, E).

THE ROOT STOCK

The most economic and speedy way is to use one-year-old root stock, and operate in mid-summer of the same year. The mango fruits chosen to supply seed for stock, must be large enough in size, if the plant is a seedling type, and it must represent a good early strain. It is not necessary to use the seeds of big varieties, like the Carabao or Golek, because all seedling types supply good stock plant for these standard mangoes. If the Carabao mango seedling is used as the root stock of the White Golek, the scion will always outgrow the stock, but the stock of the seedling type of the mango will grow just as big as the scion or will slightly outgrow it, whenever the Carabao or White Golek is worked on to it. The seeds are planted in pots or in the ground 60 cm. apart, after removing the shell. The planting soil must be well prepared and rich in organic matter. After sowing the seeds, it is desirable to have a thin sand dressing on the surface. Upon germination of the seeds, they must be tested to show only a single plant from each seed, and smaller poly-embryonic secondary sprouts must be scraped off while they are young. The seedlings should be well fertilized to allow them to attain their maximum height and girth. In starting the work, the bigger seedlings are to be worked on first, the smaller ones next. The cutting back of the top of the stock must not be carried down too far away from the parts having closer leaf stand. In top-working old seedlings, the best results may be obtained when the plant is rather large, having at least a diameter of 12 to 15 cm. That transplanting may be made easier the seed should be planted in a longitudinally halved pot. (Plates 2, 3, 4).

OPERATION AND TYING

The bottom of the scion must be cut very sharply to make an acute wedge, but one side must be cut along the cambial layer as far as possible, so that both sides are not symmetrical. The cut surface must be very smooth, allowing a single draw of the knife to make an even plane. The stock is then notched by cutting it down diagonally, and the knife must be drawn straight down to make the oblique cut very sharp and even. The side to be

incised must be as straight as possible. Curves should be avoided. It is preferable to work on the eastern side, as the afternoon sun may injure the graft when it is done on the western side. The wood tissue should not be cut too deep into and the incision must not be too far away from the cambial layer. The scion wedge to be well placed must be inserted in air-tight contact with the incision surface. The tongue-like portion of the bark must not be broader than the stock notch, even if the scion is thicker than the stock. In other words, the cambial plain of the former must be completely concealed within the incision of the stock. All precaution must be taken to make the scion wound perfectly covered by the cut surface of the stock. The air-tightness of the contact surface would decide whether the union is successful or not. A long exposure of the cut surface of the scion must be strictly avoided. Therefore, the scion ready to be used must be kept, during the operation, in a tall box to prevent its cut surface drying up. The best kind of knife to use in mango grafting is one having a blade of stainless steel and sharpened on one side only. By using such a knife, oxidation of the cut surface can be prevented. The sharp edge of the knife must be straight so as not to cause any curvature on the cut surface. The best type of tying material is ordinary cotton string tape commonly used in the shop, which is composed of several thread lines pasted flat in one narrow strip. The tape must be wound close and tight so as to exclude air. Such tape will be removed one or two months after the taking of the scion when it will have increased in volume. Waxed cloth tape generally used in budding is not satisfactory, as it prevents the quick swelling of the scion in action. (Plate 1 and Plate 5, F).

TREATMENT AFTER THE OPERATION

No cover is necessary to protect the graft even in strong sunshine. After two weeks, the uppermost bud of the scion begins to swell. If it looks difficult to judge whether the graft was successful or not, observe at night with the use of a flashlight. The surviving scion looks lustrous and turgid. After the third week, the bud starts its initial growth. The internal activity of the living graft can be easily detected with the frequent visit of ants, seeking the sugary secretion of the new growth. At this time, the top of the root stock may also show new growth. These stock shoots must be shaved off with care as soon as they start to elongate. When the new growth of the scion develops

and reaches a length of 30 cm. or so, the remaining top portion of the stock must be sawed off carefully at a point 5 to 8 mm. above the union.

If the scion did not take, the same stock can be worked again at the opposite side a little below the original incision.

Since no cover is used in the present method, precaution must be taken not to leave any wound of the scion in contact with the air. The success of the graft is therefore dependent upon the skill of the operator. Covering the grafted portion with soil helps injurious fungi or bacteria to the wound.

DISCUSSION

Mr. Nakamura's side working method of the mango is a good example of "soft wood grafting" which is generally believed unsuccessful in the tropics as well as in the colder countries. He found that the failure lies principally in the inadequate condition of the scion, and the lack of proper attention to safeguard its activity. The immature bud does not develop in most of the temperate species, except in a few, like the apple, plum, and the cherry. With most of the tropical species, however, it is easier to make such immature bud start growth, provided the forcing is done effectively. This can be attained by pre-curing the bud through defoliation and putting it into a vigorously growing stock during the active growing season, not in the springtime when the bud is semi-dormant. The strong seedling cut in summer or early fall can easily stimulate the inserted bud to growth, after a certain period of curing caused by the natural drop of the petiole which, in turn, is forced by the removal of the blade. At the same time the scion is almost water-proof as the petiole scar is already well coated with cork tissue thus preventing evaporation. All these factors favor the rapid healing of the union and the easy development of the new bud. At the end of the fall, an already well developed nursery plant can be secured, and a large number of similar plants will then be available as a good supply of the budwood can be had at intervals of approximately two weeks, as stated in the preceding paragraphs. The entire grafting work is complete at the end of the year the seeding of the stock plant is started and the resulting young plants are ready to be transplanted in the next spring. In this way standard varieties, like the Carabao and the White Golek, can be obtained in a large number within a very short time. This gives an opportunity to mango planters to raise more plants

of the desirable variety with less expense and labor. This fact also suggests the possibility of the mango trees being planted on a large scale as a plantation crop, since the demand for fresh fruits has increased after the invention of preparing the frozen mango meat for use in ice-cream manufacture. The canning of the mango meat is also a great possibility in tropical countries. Fruits of such varieties like the Carabao and the White Golek can be picked green before the mango fruit fly, *Chaetodacus dorsals* Hendel has a chance to attack them. They can then be satisfactorily transported and marketed before they get over-ripe. It is hoped that the present paper may be of help in the future development of the mango industry in the Far East.

ILLUSTRATIONS

Plate 1

Young stock plant cut back (one leaf remaining) with the scion already side-grafted. Note new shoot with a whorl of already developed leaves. Photographed on June 20, when there were still mango fruits in the market (left, Carabao; right, seedling type).

Plate 2

Vigorous new shoots of two scions side-grafted on two opposite stocks arising from a large mango branch. Branch and stocks have been cut back. This was done in early fall when Kaki fruits could still be purchased in the market (two fruits are shown at the bottom).

Plate 3

Stocks in row, photographed on June 2. *A*, side graft showing the scion with complete first cyclic growth. *B*, older side graft showing the top of the scion already removed. The scion had already completed the second cyclic growth. *C*. same as *A*. *D*, stock with one shoot saved, ready to be top-worked. Originally top of stock was cut back and one shoot saved from resulting adventitious buds. The new shoot is shown already making the third cyclic growth.

Plate 4

The same stocks, photographed on July 15. *A*., side graft showing the scion with complete second cyclic growth. The top of the stock is ready to be cut off. *B*, new shoot with complete third cyclic growth. *C*, same as *A*. *D*, the top of the stock shoot was cut back and side grafting done after taking the photograph shown in Plate 3. The new scion has already completed the first cyclic growth. Photographs taken when mango fruits could still be purchased in the market (left, seedling type; right, Carabao).

Plate 5

A, typical mango budwood. *B*, leaves are removed by cutting them off at the petiole. *C* and *D*, natural abscission of the remaining petioles. *1*, *2*, *3*, pieces available for sciòn. They are to be cut off from the top at intervals of about two weeks, as soon as the cut surface is healed. *E*, side grafting on a root stock cut back. *F*, the same, tied with narrow thread tape.

PLATE 1.

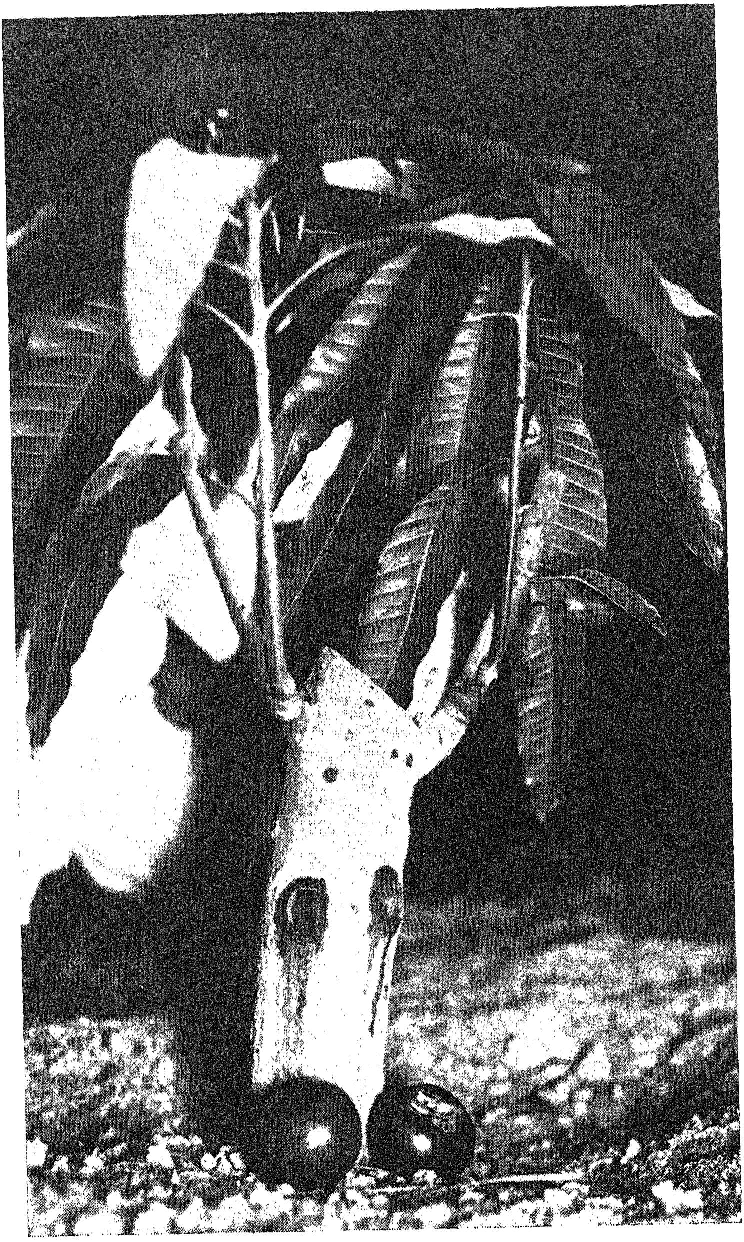

PLATE 2.

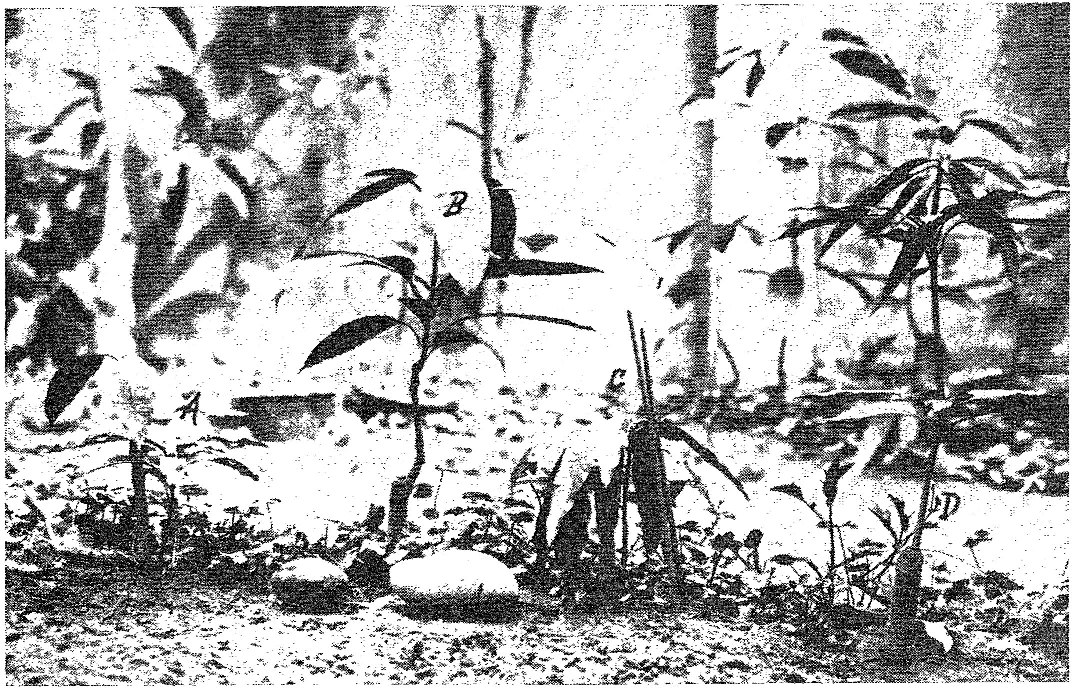

PLATE 3.

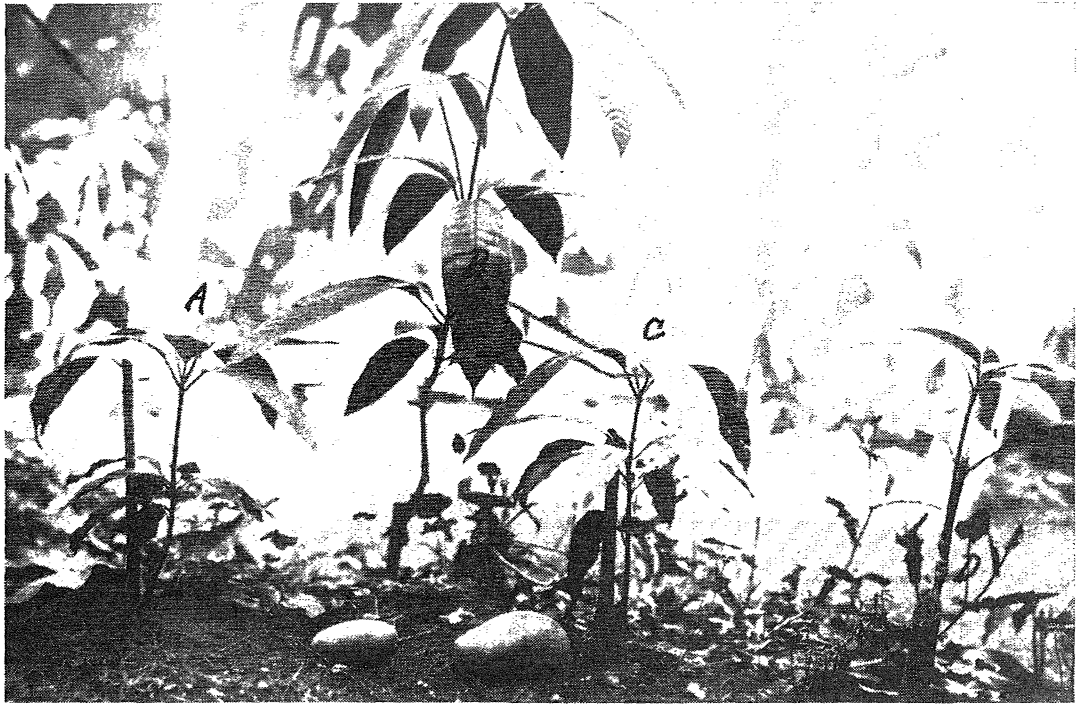

PLATE 4.

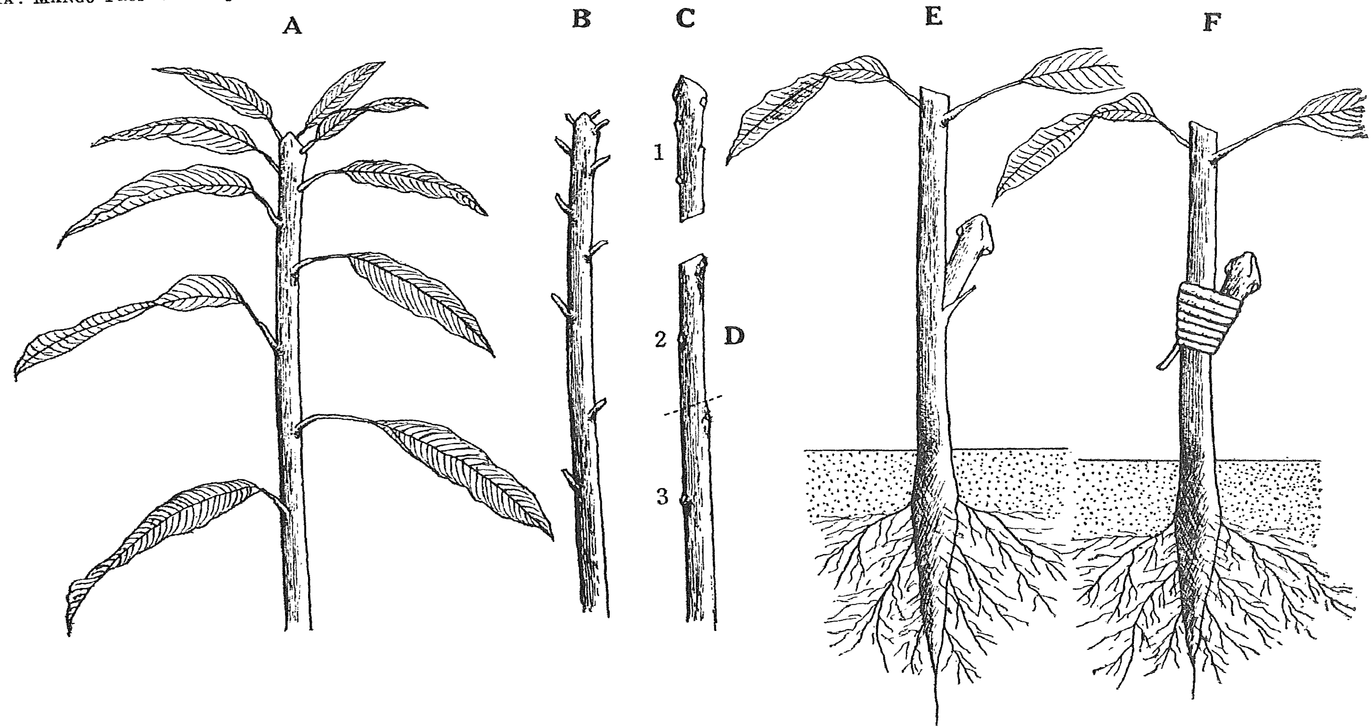

PLATE 5.

SOME NOTES ON TONGUE-INARCHING OF THE AVOCADO

By JUAN P. TORRES

Of the Bureau of Plant Industry, Manila

EIGHT PLATES AND TWO TEXT FIGURES

The vegetative propagation of plants, known as tongue-inarching which is briefly described in this article was first practiced successfully with the avocado at the Economic Garden, Los Baños, Laguna. The same method of inarching is termed "whip grafting" or "grafting by approach" and is briefly described in the Standard Cyclopedia of Horticulture, Volume III F–K, page 1370. As a part of the lecture on Plant Propagation, this method was demonstrated by the writer to most of the trainees under Commonwealth Act No. 85, while in their training period at the Economic Garden. To these trainees who are now stationed in many parts of the country, from northern Ilocos down to Sulu Archipelago, this method was locally referred to as the E. G. method of inarching, to differentiate it from the ordinary method of inarching.

PREPARATION OF STOCKS AND SCIONS

The stocks for inarching must be in a vigorous growing condition before attempting to unite them with the twig-scions. The seeds may first be grown in seed flats and then potted as soon as they have germinated. Pots not less than four inches, inside diameter, or good sized bamboo joints may be used for the purpose. Always use rich loam or sandy loam soil. If for any reason the seedlings had been grown in the nursery rows before potting, larger sized pots must be used. For extra large-size seedlings half or whole empty petroleum 5-gallon cans should be employed.

After the seedlings are well established in the pots and are growing vigorously, inarching may be done on any part of the tree, either near the ground if the branches are low or high up on the tree. In the latter case the pots with seedling stocks may be "hung on a branch near the twigs to be inarched,"(1) Plate 1. With side branches, a platform or a stout scaffold

should be constructed at a suitable level around the tree which will furnish the twig-scions, Plate 2. The scions should be the most vigorous twigs and, if possible, of the same size as the stem of the intended stocks. Stems of stocks and scions of the same size may not be very essential for a stock a little larger than the twig-scion will also make a perfectly good union provided that both of them are in a vigorous growing condition.

Method of inarching.—As in the ordinary method of inarching (2) (3), the bark and part of the wood of both the stock and the scion are removed with a clean cut by means of a sharp knife. As much as possible both cuts should be of the same width and length, about 2 to 3 inches long, so as to make a snug fit when the two cut surfaces are brought together. Then, a little below the top of the cut surface of the stock make a split downward, figure 1(*a*), and another same-sized split upward or "tongue" on the cut surface of the twig-scion, figure 1(*b*), and then the stock and scion are brought together as shown in figure 1(*c*). The "tongue" on the twig-scion is inserted into the split on the stock so that the cambia of the stock and scion are brought into as much as possible a close contact. Held firmly in such position, they are then bound together by wrapping with budding tape or waxed cotton twine. Both the pot with the stock as well as the twig-scion are fastened firmly so as to prevent dislocation of the stock and scion by any movement due to wind or otherwise.

During rainy days one must be sure that, after tying, no water enters the wound, otherwise there will be no union. The stocks should be regularly watered when the weather is dry so as not to retard the union and produce weak inarched plants.

Three to four weeks after inarching, to be more exact, 25 to 30 days, the top of the stock may be removed by cutting off obliquely at a point shown by the tip of the pruning knife on the left side, Plates 3 and 4. The cut surface should be painted with either white lead or asphaltum. By this time the stock and the scion had already united to a greater or less extent. A cut on the side about one-half of the stem in depth is made into the wood of the scion as shown by the point of the budding knife on the right side, Plates 3 and 4. Within two weeks or more after the first cut is made the appearance of vigorous shoots in the scion indicates that the sap is moving freely through the union. No sooner has such growth started than the

inarched plants are severed from the mother plants, Plate 5. The cut surface is smoothed with a sharp knife and, as before, painted with either lead or asphaltum. Thereafter the inarched plants are kept temporarily in a plant shed until they become

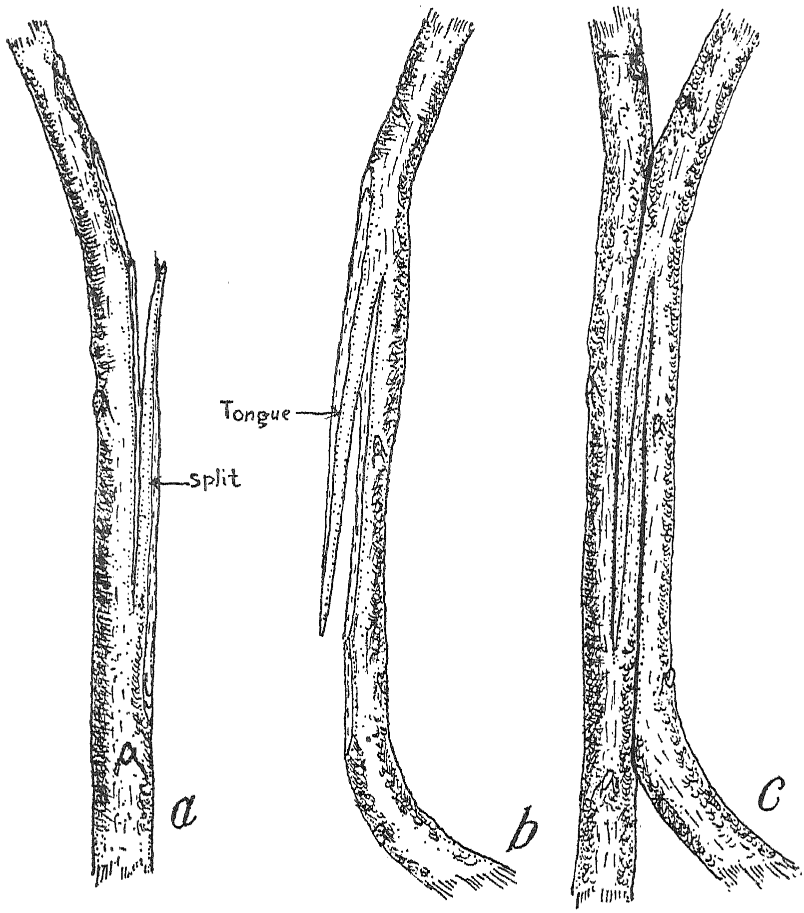

FIG. 1. Illustrations to show (*a*) the downward split on the stock (*b*) the upward split or tongue on the twig-scion and (*c*) the stock and twig-scion being brought together.

fairly well established. Then they are set in a half-shaded place until they develop a perfect union and strong tops, Plate 6, when they are ready for transplanting.

TONGUE-INARCHING VERSUS ORDINARY METHOD

With the method just described in the preceding paragraphs it is very plain that the line of contact between the cambia of the stock and the scion has been greatly increased. As may be

seen in the illustration, Fig. 2(*a*), the ordinary method of inarching has only one line of contact whereas, in the improved method, Fig. 2(*b*) there are three lines of contact, hence a greater chance for union. Because of this increased line of contact between the cambia of the stock and the scion in the modified method, the period from the date of inarching to the date of severing the inarched twigs from the mother plant has been

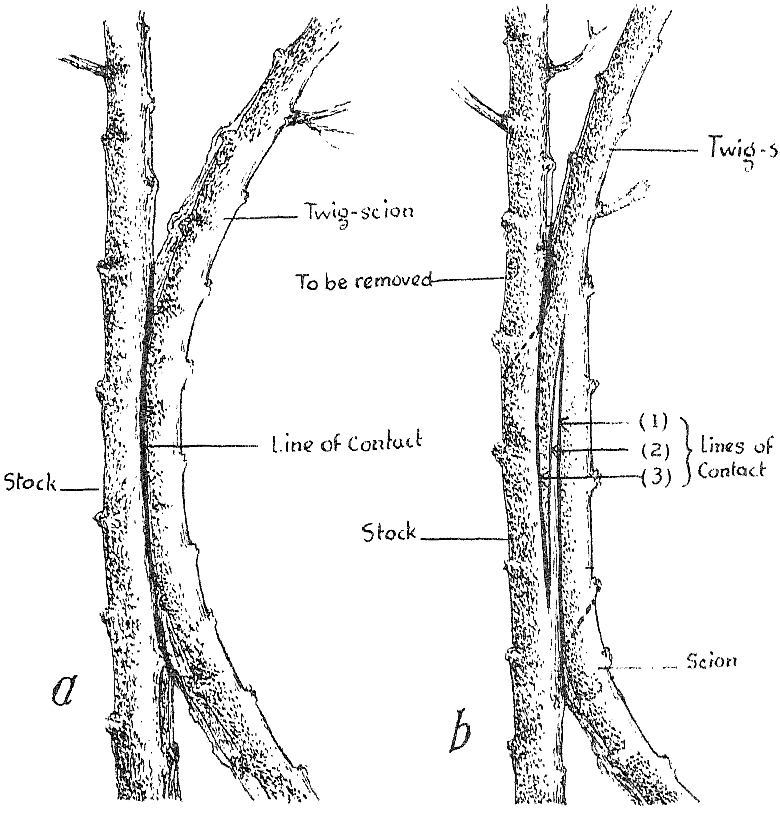

FIG. 2. Illustrations to show the line of contact between the stock and the scion in (*a*) ordinary inarching and the three lines (1, 2, and 3) in (*b*) the improved method of inarching. The dotted lines indicate where to cut off the top of the stock and where to sever the inarched twig from the mother plant.

shortened by four weeks or more. With the ordinary method of inarching this period takes from 8 to 12 weeks or more.

The inarched plant by this method is more firmly united with the stock because of the "tongue" of the scion which is inserted into the split in the stock. Obviously the inarched plant is in fact a "tongue grafted" plant. For the same obvious reason the sap flows more freely through the union thus resulting in a more rapid development of the inarched plants.

A set of 100 twigs of the avocado, Batangas Cardinal No. 2, were inarched using the improved method. On the twenty-fifth day all the tops of the *stocks* had been removed and in *42 days* from the date of inarching, all except two twigs had been severed from the mother tree. One of the twigs broke off on the thirtieth day as the pot bearing the stock fell to the ground. This particular branch continued to develop but very slowly. The other stock used was too young and was badly infected with a fungus disease which proved fatal. Three other twigs developed very slowly and, upon examination, they were found to unite with the stocks only in the line of contact No. 2, that is, between the tongue of the scion and the split in the stock. Nevertheless, three to four weeks later, both of them had developed normally. This preliminary trial with tongue-inarching gave about 95 per cent perfect union. On the other hand, of the 30 twigs inarched with the ordinary method, which were severed 3 months after inarching, two died in two weeks and six were apparently very weak; hence there were only 20 living twigs or 66 per cent perfect union.

In ordinary inarching a perfect union may be obtained when the stock and scion are both in vigorous growing condition and of the same size but in tongue-inarching, the stocks and the scions may be of unequal size. If not as large as the twig-scion, the stock must be a little larger, if there should be any difference in size. This does not mean that stocks that are smaller than the twig-scions will not unite as it has been observed that they do unite equally well with the improved methods of inarching. The part just below the union, however, may remain small for a considerable length of time.

TONGUE-INARCHING VS. OTHER METHODS OF PROPAGATION

Tongue-inarching on the avocado may now be compared with such other methods as marcotting, grafting and budding. Experience has shown that most of the avocado varieties do not root when marcotted. Some avocado trees may root but the percentage of success is too low to recommend the method for commercial propagation. San Pedro (4) stated that all the 182 branches in 3 avocado trees which he marcotted had formed complete calluses in 6½ months and there had appeared prominent protuberances in the upper region of the ring, which he found, had given rise to roots a month after excising the

calluses below them. From his trials he obtained a very low percentage of perfect rooting. With the avocado, therefore, marcotting is an operation that requires a much longer period to perfect but gives a lower percentage of success than tongue-inarching.

The propagation of the avocado by grafting is more exacting in the vigor and size of stocks as well as in the quality of bud-sticks for scions than in improved inarching. The percentages of success obtained in the Economic Garden at Los Baños, Laguna ranged from 20 to 40 per cent in spite of considerable skill in performing them.

Budding is the commercial method of propagating the avocado. It requires no less amount of skill than grafting to perform it successfully. The best season for budding is during the cool months, from the latter part of November to the first week of March. The rainy season is indeed an unfavorable time for budding the avocado for most of the buds drop off and the shields become "blind." In exceptionally favorable season the highest percentage of success obtained from budding the avocado was about 65 per cent, and 30 to 40 per cent success is a fair general average. There are types of the avocado that, due to poor quality of their buds, are not so easily propagated by budding. Tongue-inarching seems to do well with them. Unlike grafting and budding, tongue-inarching may be more easily done during the wet season as then the stocks need less frequent watering than during dry weather. However, with an adequate water supply inarching may be done successfully in both seasons, wet and dry. With fast growing selected types of avocado plants in the orchards having numerous low set branches, it is certainly not only advisable but also more profitable to adopt tongue-inarching for commercial propagation than merely pruning them off as useless or undesirable branches. This improved method of inarching can easily make use of overgrown stocks unsuitable for budding and grafting, and it would undoubtedly serve well as a supplementary method of propagation during rainy days when budding and grafting are less successful.

APPLICATION OF THE TONGUE-INARCHING METHOD

Tongue-inarching has been found to be successful with many other plants such as chico, lanzon, sweet guayabano, caimito, rambutan, atemoya, biriba, and seedless mabolo but has not been used so extensively with these plants as with the avocado.

Recently, however, the Plant Propagation Division of the Bureau of Plant Industry tried this method in the multiplication of rambutan, with rambutan stocks, Plate 7; and Ponderosa chico with St. Croix chico as stocks, Plate 8, so as to supply the demand for these fruit trees. In the Economic Garden, the new method has been tried successfully on lanzon stocks, and on longan with lichi seedlings as stocks. It is also believed that this method may be easily adopted in the propagation of other fruit plants such as grapes, if it is desired to provide better root systems, using the most adaptable variety as stocks for the newly introduced ones. In this case rooted cuttings of both the stock and the scion should be inarched.

SUMMARY

The method of propagating the avocado described in this paper is a modified method of inarching, a combination of ordinary inarching and the so-called "tongue grafting."

In this method the line of contact between the cambia of the stock and the scion is greatly increased, thereby shortening the period from inarching to the date of severing the inarched twigs from the mother plant by four weeks or more.

The preliminary trials with the improved method versus the ordinary method showed 95 per cent perfect union for the improved or E. G. method of inarching as against 66 per cent for the ordinary method.

Not only has the new method yielded decidedly better results than marcotting and grafting with the avocado but with its use overgrown stocks unsuitable for grafting and budding can be easily utilized to advantage. Finally, it serves well as a supplementary method of propagation in the nursery during rainy days when grafting and budding can not be done very successfully.

Tongue-inarching had been tried with success on chico, lanzon, sweet guayabano, atemoya, biriba, seedless mabolo, and others.

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ILLUSTRATIONS

PLATE 1.

PLATE 2.

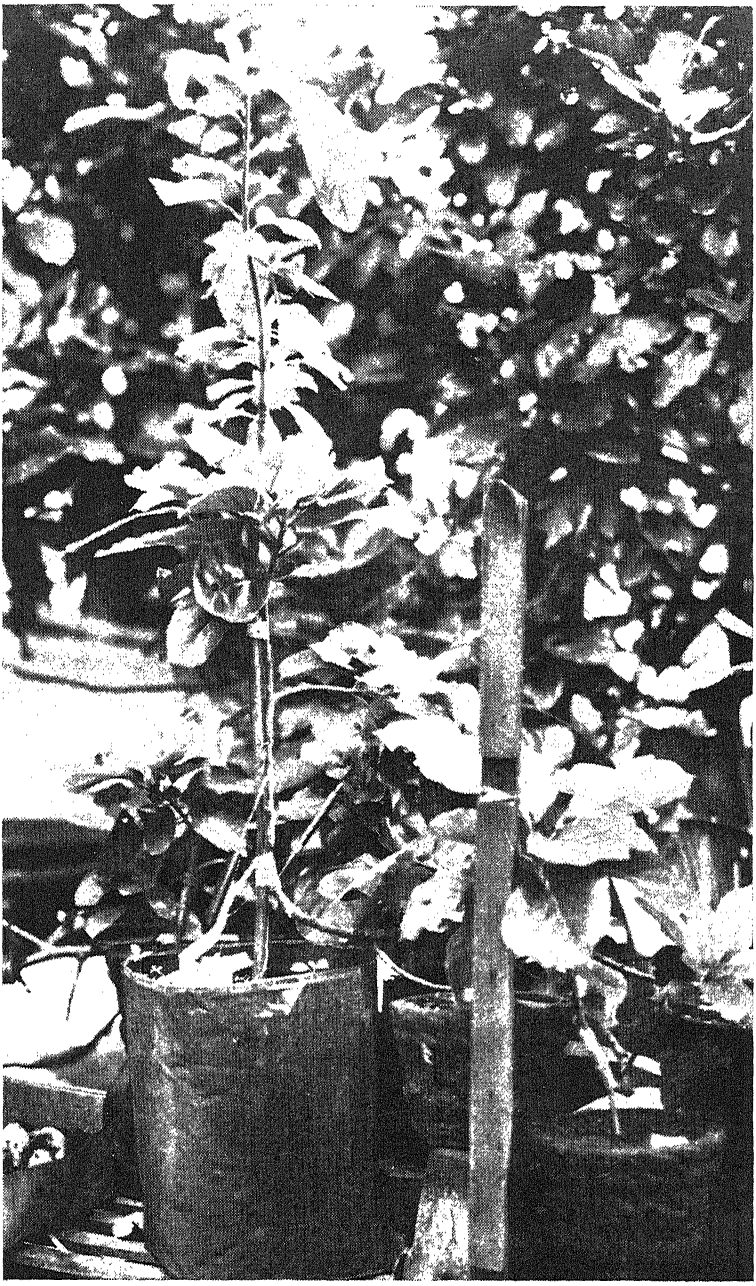

PLATE 3.

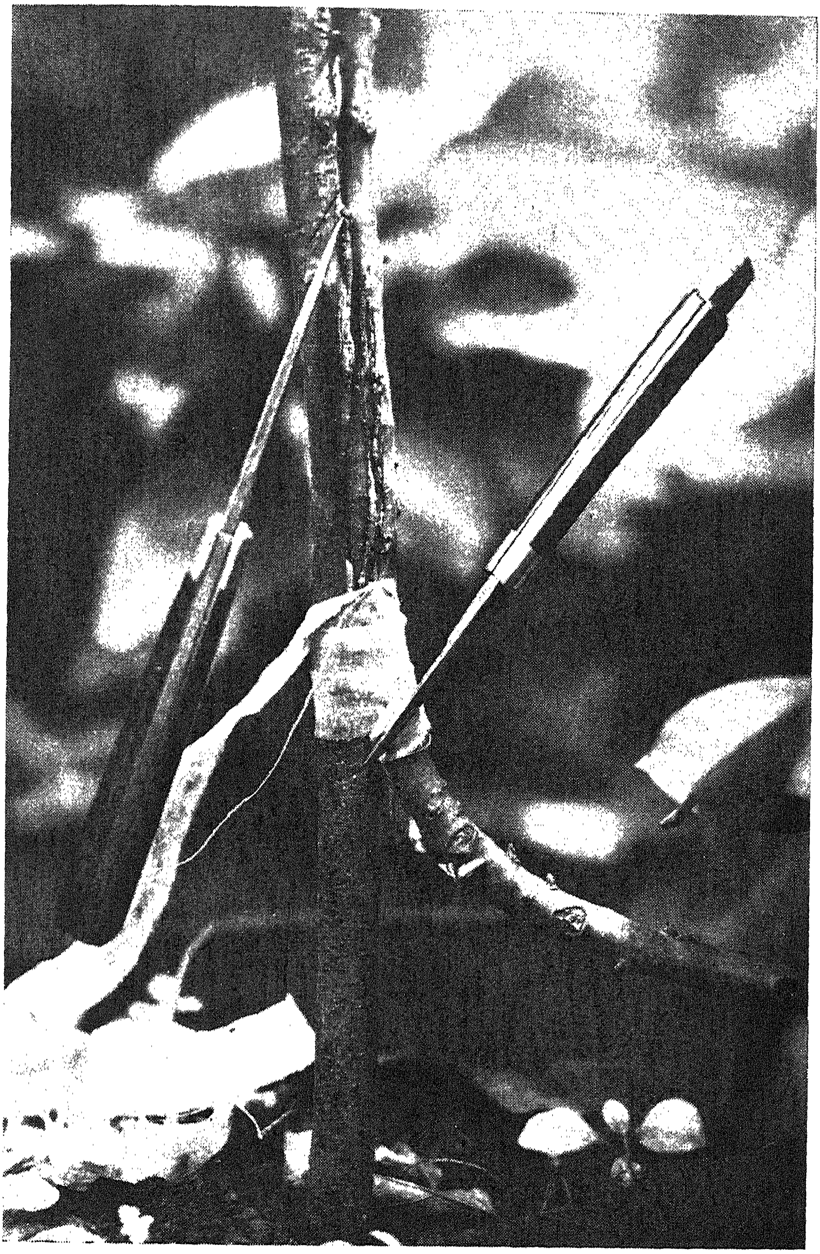

PLATE 4.

PLATE 5.

PLATE 6.

PLATE 7.

THE PILI NUT IN THE BICOL REGION

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FOUR PLATES

INTRODUCTION

Included in our agricultural wealth, still barely tapped, figures the pili nut which is perhaps the second most important nut fruit in the Philippines. Although considered a natural product of our country, found wild or semi-wild in many parts of the Bicol region, Mindoro, Tayabas, Laguna, Visayan Islands, and Mindanao, and although the nuts are considered exquisite by many, a majority of the people in the Islands, not to mention other countries, do not know the excellent qualities of this nut. It is a fact that in Europe as well as in America many have not even heard of the name, much less tasted the nut or preparations made from it. It is, however, very probable that, once this nut enters the world's market in good condition, it will offer stiff competition to the other nuts of commerce.

BOTANY

Pili belongs to the Family *Burseraceæ* to which also belong quite a number of species. According to Merrill (1) there are four genera under this family, of which Canarium is one, and about 40 species in the Philippines. Of the genus *Canarium* he has mentioned there are about 35 species in the Philippines.

Some authorities believe that there are three or four species of pili in the Islands, of which only two yield the highly priced nuts. These are *Canarium ovatum* Engl. and *C. luzonicum* (Blume) Gray, with the following descriptions:

C. ovatum is a fairly big tree that reaches a height of about 20 meters and a trunk diameter of about 40 cm.

Leaves alternate and compound with opposite smooth leaflets which are rounded at base and pointed at tip. Leaflets from 10 to 20 cm. long.

Fruits 6 to 7 cm. long, light greenish or yellowish green when young, turning deep maroon to violet black when ripe. The fruit consists of a thin to fairly thin pulp covering the triangular nut that has rather hard and thick shell.

The pulp is edible when cooked and contains an oil which is occasionally extracted locally for lighting and cooking purposes.

Kernel rich in oil, sweet, and suitable for culinary purposes; deliciously flavored when cooked.

C. luzonicum reaches a height of about 35 meters and a diameter of one meter.

Leaves odd pinnate with three pairs of opposite leaflets that are smooth, pointed at apex and rounded at base. Leaflets measure from 12 to 20 cm.

Fruits oval-shaped, about 3 cm. long, containing thick shelled triangular nuts with edible kernels covered by pulp as those of *C. ovatum*.

BEGINNING OF THE INDUSTRY

There seems to be no definite record as to when pili became first known nor when it became cultivated in the Bicol region. So far as the writer is aware there is no literature on the subject. Suffice it to say that trees a hundred years or more old are found in many places in the region and have been taken advantage of by the people. It must be admitted therefore that the plant must have been known in this region long ago.

PROGRESS OF THE INDUSTRY

The advance registered by the pili industry in acreage and in the uses of the nut since its introduction to many farms in the region has been quite slow as may be seen from the following tables:

TABLE 1.—*Showing the acreage and number of trees in the Bicol mainland.*

Provinces	Years							
	1932 [a]		1933 [b]		1935 [c]		1936 [d]	
	Area	Trees	Area	Trees	Area	Trees	Area	Trees
	Ha.		*Ha.*		*Ha.*		*Ha.*	
Albay	460	57,490	477	59,670	482	60,200	477	59,650
Camarines Sur	297	37,130	313	39,060	309	38,600	311	38,850
Camarines Norte	45	5,560	42	5,230	54	6,740	56	6,980
Sorsogon	214	26,770	225	28,170	244	30,500	246	30,720

TABLE 2.—*Showing the number of bearing and non-bearing pili trees in the Bicol mainland.*

Provinces	1933 [b]		1935 [c]		1936 [d]	
	Bearing	Non-bearing	Bearing	Non-bearing	Bearing	Non-bearing
Albay	45,670	14,000	46,220	13,980	45,190	14,460
Camarines Sur	29,160	9,900	29,010	9,590	29,840	9,010
Camarines Norte	3,760	1,470	4,120	2,620	4,200	2,780
Sorsogon	21,880	6,290	22,260	8,240	22,830	7,890

[a] Statistical Handbook of the Philippines. 1932.
[b] The Philippine Statistical Rev. *1*:4. Fourth Quarter.
[c] The Philippine Statistical Rev. *3*:4. Fourth Quarter.
[d] The Philippine Statistical Rev. *4*:1–2. First and Second Quarters.

TABLE 3.—*Showing the average yield per tree.*

Provinces	1932 [a]	1933 [b]	1935 [c]	1936 [d]
	Kilos	*Kilos*	*Kilos*	*Kilos*
Albay	44	45	42	41
Camarines Sur	25	29	30	30
Camarines Norte	38	39	38	45
Sorsogon	33	34	31	31

[a] Statistical Handbook of the Philippines. 1932.
[b] The Philippine Statistical Rev. *1*:4. Fourth Quarter.
[c] The Philippine Statistical Rev. *3*:4. Fourth Quarter.
[d] The Philippine Statistical Rev. *4*:1–2. First and Second Quarters.

It can be seen from these tables that the production of, and acreage devoted to pili, has not increased much due possibly to the semi-wild state of the trees, and to a poor comprehension of its possibilities. An actual count of fruits of a fairly good bearing tree at Banao, Guinobatan, Albay, showed 10,000 nuts produced by a tree about 45 years old. These make up about 4½ sacks of fresh fruits or 83 kilos of air-dried nuts.

Pili nuts, although not so well cared for as they should be in the region, mean something in the economic set-up of the Bicolanos. For instance, in 1934 pili as a crop ranked 6th in value in the agricultural production of Albay, yielding nuts valued at ₱86,710; 9th in Camarines Norte with ₱8,410; 5th in Camarines Sur with ₱66,840; and 8th in Sorsogon with ₱38,830. (2)

There is none that can be considered a real plantation so far in the region, the present trees being either wild or semi-wild. In most cases they are, intentionally or unintentionally, used as shade trees for abaca; or, are planted together with coconut trees. A very negligible number are planted and cared for, save those set around school houses, around yards or houses, and along highways. Practically all trees have been or are "chance" growths—from fallen fruits carried away by birds.

Although quite a number of trees have been felled for fuel or in making way for a clearing, the number of trees planted is slowly but steadily increasing.

DISTRIBUTION

Albay.—Of the 16 municipalities of Albay mainland, namely, Libon, Polangui, Oas, Ligao, Guinobatan, Jovellar, Camalig, Daraga, Tabaco, Malilipot, Legaspi, Manito, Libog, Bacacay, Malinao, and Tiwi, most of the trees are found in the towns of Guinobatan, Ligao, Camalig, Daraga, Tabaco, Malilipot, and

Libog—municipalities immediately surrounding the Mayon volcano—although trees may also be found in the municipalities of Bacacay, Malinao, Tiwi, Polangui, and Jovellar especially among the abaca plantations.

Again, it may be stated that even in the municipalities having the most pili trees, their distribution is confined to some barrios. For instance, in Guinobatan most trees are located in barrios Banao, Binogsacan, Mauraro, Masarauag, Muladbucad, Bubulusan, Balobago, Agpay, Tagbac, Lomacao, and Malipo; in Ligao, barrios Bantayan, Abibling, Nasisi, and Barayong; in Daraga, barrios Palañgo, Gapo, Anislag, Kilicao, Tagas, Madaat, Inarado, Balinad, and De la Paz. The same is true with the other municipalities (see map).

Camarines Norte.—This province has relatively fewer trees than the other provinces of the Bicol mainland. Of the 9 municipalities, namely, Basud, Daet, San Vicente, Talisay, Indan, Labo, Paracale, Pañganiban, and Capalonga only Basud, Daet, Indan, and Labo count with an appreciable number of pili trees. Observations seem to indicate that, as in Albay, the pili trees are found to thrive well among the abaca and coconut plantations.

Camarines Sur.—There is at present no regular pili plantation in any of the 32 municipalities of the province, although an aggregate area of more than 300 hectares is planted to this crop. Of the different municipalities, namely, Del Gallego, Ragay, Lupi, Sipocot, Libmanan, Cabusao, Pamplona, Pasacao, Gainza, Camaligan, Canaman, Magarao, Calabang, Tinambac, Siruma, Naga, Milaor, San Fernando, Minalabac, Pili, Bula, Tigaon, Goa, San Jose, Lagonoy, Caramoan, Sañgay, Baao, Iriga, Nabua, Bato, and Buhi, those comprising the Rinconada and Partido districts have the most pili trees although other municipalities like Libmanan, Magarao, Camaligan, Gainza, Milaor, Naga, and Calabanga have trees here and there (see map).

In the Rinconada district which is composed of the municipalities of Iriga, Buhi, Nabua, Baao, Bato, and Bula, most of the pili trees are confined to some barrios of the four first-mentioned places. In Iriga most trees are located in San Nicolas, San Agustin, San Isidro, Salvacion, San Francisco, Sto. Niño, and San Antonio; in Buhi at barrios Sagrada Familia, Lourdes, Boraboran, Tambo, and Antipolo; in Nabua, at barrios Santiago, Sto. Domingo, La Purisima, Lourdes, Antipolo, San Ramon, and Santiago (Small); in Baao, in barrios bordering the municipalities of Iriga and Nabua.

In the Partido district which is composed of the municipalities of Tigaon, Goa, San Jose, Sañgay, Caramoan, and Lagonoy only barrios Salvacion and Tinaugan of Tigaon have an appreciable number of pili trees; Sañgay, barrios Nato and Kitubay; Goa, barrios Matacla, Buyo, Masawan, and Pinaglabanan; Lagonoy, barrios Duhat, Palale, and San Rafael; San Jose, barrios Dalasan, Salogan, and Baybay.

Sorsogon.—Practically all of the municipalities of Sorsogon, namely, Bacon, Barcelona, Bulan, Bulusan, Casiguran, Castilla, Donsol, Gubat, Irosin, Juban, Magallanes, Matnog, Pilar, Prieto-Diaz, Sorsogon, and Sta. Magdalena, have pili trees. In these 16 municipalities, however, most of the pili trees are to be found either with abaca or coconut trees especially in the towns of Bacon, Barcelona, Bulusan, Donsol, Irosin, and Sorsogon (see map). Again, even in these municipalities as in other parts of the region, most trees are confined to some barrios as follows:

Bulusan: San Francisco, San Isidro, Capilihan, San Jose, and San Bernardo.

Donsol: Lomtao, Baras, Bamban, Paroras (San Jose), and San Isidro.

Irosin: Lomboon, Gabao, Monbon (at sitio Batang), Patag (at sitio Bangkó), and Bagsañgoan.

Sorsogon: Burabod, Bibingcahan, Aboyog, and Roró.

Bacon: San Juan, Maricrom, Del Rosario, Buñga, Sugod, San Roque, Balite, Sto. Domingo, and Sta. Cruz.

Barcelona: Bacabaré, Layog, and Togdon.

Prieto-Diaz: Calao and Cayo.

Gubat: Rizal.

AREA FOR PILI PLANTING

There are still fertile and wide areas of land in the four provinces of the Bicol region that are suitable for the planting of pili. Given good and steady prices, not to say assured of a steady outlet, Bicol farmers, with constant and proper information, would be willing to extend the planting of this crop. Areas, from sea level to 400 meters(3) or slightly over, suitable for the crop are still available especially in Camarines and Sorsogon.

CULTURE OF PILI IN THE REGION

Although the nut is popular among the Bicolanos and is a rare table delicacy, and although others consider it even superior to the almond, no exploratory work on or varietal studies of it have ever been undertaken. With the exception of a negligible number around school houses and in a few backyards, pili trees are

grown by chance in the region, from fallen nuts or nuts carried by birds. In fact most of the pili trees in the region are in a semi-wild state. Practically no care, whatever, is given them. They are taken as a matter of course by the Bicolanos. Hence it is that it seems the old adage "familiarity breeds contempt" applies with the Bicolanos.

In its natural habitat, pili thrives thriftily in the humid places with a more or less even distribution of rainfall. This is almost precisely the condition obtaining around Mount Iriga, Mount Isarog, Mount Mayon, Mount Bulusan, and other places where pili trees thrive well. According to Wester and substantiated by the present observations, pili trees do well at fairly low elevations—from sea level to 400 meters or slightly over, and in places where the soil is fertile and well drained. Even in clay loam soils provided these are well drained and in slightly stony places with enough soil, they have been observed to do well.

PESTS AND DISEASES

So far as is known, pili is rarely attacked by any serious pest or disease. This is borne out by testimony of people in the region and personal observations by the writer. Certain borers and fungi have been found, however, in samples of immature fallen nuts from Buhi, Camarines Sur; Mauraro, Albay; and Donsol, Sorsogon. Efforts in getting more specimens have nevertheless proven futile. For this reason, Mr. Juan de Vera, municipal agricultural inspector for southern Camarines Sur, has been requested to send specimens to the Plant Sanitation Division of the Bureau of Plant Industry.

PREPARATION OF PILI FOR MARKET

As a whole the removal of the pulp of the fruit preparatory to marketing either locally or in Manila is by scalding. The procedure is as follows:

Water is first heated in a vat or in a kerosene can to a temperature hot enough to scald the hand. Freshly gathered nuts are then immersed in the water and kept there until the pulp or husk comes off easily when pressed with the hands. At this point the fruits are removed from the water and immediately pulped by hand.

After removal of the pulp the nuts are rinsed with cool water and dried in the sun before they are packed in sacks or bags for marketing. The current price of the unprepared and prepared nuts is from 8 to 10 centavos per 100 nuts, and 6 to 8

centavos per kilo, respectively, depending upon their size, the time and place.

When the water is too hot and the fruits are left in it beyond a reasonable length of time, that is, beyond the point when the pulp gets off easily upon pressure of the hand, the husk slightly shrinks and becomes hard and difficult to remove.

Several methods of pulp removal were tried by Austria(4) as follows:

(1) By hand:
  (*a*) Crushing the pulp on a cement floor by pounding nuts with a piece of wood, taking care that the force is just enough to break the pulp but not the hard shell.
  (*b*) Scraping off the pulp with the use of knife.
(2) Retting in tap water (25°C. to 28°C.) using kerosene can containers.
(3) Placing the nuts on the ground under the shade of a tree. Ants, worms, and termites visited the place and ate part of the husk.
(4) Hot water treatments: Fruits were soaked in hot water until the husk could be removed easily. Temperatures used were 40°C., 50°C., 60°C., 70°C., and 80°C.
(5) Chemical treatments: Using 5 per cent and 10 per cent solutions of commercial potassium hydroxide (KOH) and sulfuric acid (H_2SO_4).

Austria summarized his findings as follows:

(1) Soaking the nuts in water heated to a temperature of 40°C. to 50°C. was most practical and recommendable.
(2) Below 40°C., the removal of the husk was greatly delayed.
(3) Above 50°C., the nuts in storage became rancid in a short time.
(4) At 80°C., the kernels became rancid in a month and the germs dead.
(5) At 60°C., about 50 per cent of the nuts in storage got rancid in 6 months.
(6) At 40°C., the nuts remained in good condition for a year or more.

Observations seem to show that in the removal of the pulp with hot water, in the Bicol region, the temperature used is not at all taken. The only consideration made of it is the ease with which the pulp is removed when pressed with the hand.

PAST AND PRESENT USES OF PILI

Pili is useful not only because of the fruit but also because of the tree itself. Its bark yields "brea" or Manila elemi (salong, Bicol). The word is almost as good a fuel as that of the mangrove or "bacawan" and ipil-ipil (*Leucaena glauca* L.).

Although the nuts are getting popular locally more and more, the elemi is still important in the world's market, it being used

in the manufacture of certain varnishes and various chemical ingredients of medicinal value.(5) The best buyers of this gum are the United States and Germany. In 1926, 1927, 1936, and 1937 the following constituted their importation from the Islands:(6)

	Kilos	Value
1926	312,718	₱146,284
1927	340,584	89,810
1936	240,881	59,424
1937	320,918	64,943

It is possible that in the past the Bicolanos made use of the gum (elemi) of the pili for lighting purposes, its wood for fuel, and its fruit for food. The fruit used to be eaten raw. With more knowledge on the subject, however, several preparations from the nut have been devised.

The pulp which is commonly used in many a Bicol home is, like before, eaten off-hand after scalding the fruit and after removal of the tough outermost covering. Sometimes an additional ingredient or ingredients as mentioned below are added before eating it, as:

(*a*) With a little salt.
(*b*) With a little salt and vinegar put to taste.
(*c*) With a little "balao" (Bicol term for salted very small fishes or crustaceans).
(*d*) With a little "patis" (liquid formed in the making of the balao) put to taste.

It is also sometimes used in the making of condiment although this is rarely done. In some instances an oil is extracted from the pulp and is used as olive oil and for native medicinal purposes. According to Mrs. R. Biron of Tabaco, Albay, 500 nuts would yield about ¼ liter of oil. She has given the following instructions in the extraction of the oil:

(1) Scald the ripe fruits.
(2) Express the milk from the pulp as of grated coconut.
(3) Sieve the milk with the use of a fine cloth.
(4) Let stand the liquid for some time.
(5) Take the upper portion having the oily matter and boil to evaporate the water as in making coconut oil.

As in the past the pili kernels or cotyledons are eaten off-hand raw or with other ingredients as follows:

(1) Whole kernels or after halving and removing the membraneous brownish covering the kernels are mixed with enough muscovado sugar of a thick syrupy consistency and when about ready to be put out of the fire they are made into different forms. This is almost the same process as in the making of the "Mayon" pili candies.

(2) Cotyledons mixed with dissolved refined sugar of a thick syrupy consistency as in (1) and before being made ino forms of usually one centavo a piece. These are the most common pili nut candies sold locally anywhere in the Bicol region especially at the truck station of Ligao, Albay.

(3) Mixed with grated young coconut meat and cooked with syrup.

(4) Mixed with coconut milk (expressed from mature coconuts) and then cooked with sugar. The pastry is removed from fire so that it is either in liquid or solid form.

(5) Mixed with grated "condol" (*Benincasa hispida* Cgn.) and cooked in syrup, a pastry that is very common in the Bicol region at wedding celebrations, baptismal parties and the like.

(6) Ground and mixed with other ingredients in the making of confectioneries as "turron", pudding, rolled jelly, etc. Mrs. Patricia S. Aduviso of Nabua, Camarines Sur, gave the following formulae for these pastries:

(*a*) TURRON (Kendeng pili)

Pili	300 nuts
Sugar	1 kilo
Milk (condensed)	1 small can
Eggs	8
Anis	1 spoonful
Sweet potatoes	$\frac{2}{3}$ of pili
Vanilla	1 teaspoonful

Peel and cook the sweet potatoes. Mix with the pili kernels. Grind the mixture together with anis. Beat the eggs and then mix with the milk and again mix with the ground pili. Melt the sugar and after about 20 minutes add the mixtures. Wait until the desired point and then let cool. Cut to desired forms. For painting the Kendeng Pili mix little condensed milk with the yellow of the egg.

(*b*) PUDDING

Mashed potatoes	2 cups
Ground pili kernels	2 cups
Refined sugar	$1\frac{1}{2}$ cups
Condensed milk	$\frac{1}{2}$ cup
Eggs	3 pieces
Butter	3 tablespoonfuls
Vanilla	1 teaspoonful

Boil potatoes until soft and peel. Mash and add the pili, sugar, butter, milk, and the well beaten eggs. Stir until smooth. Add the flavoring (vanilla) and continue stirring for a while. Put the mixture in forms, say small boxes of Manila paper. Bake in an oven with moderate heat until the color is light brown.

(*c*) JELLY ROLL

Squash (mashed)	1 cup
Ground pili kernels	$\frac{1}{2}$ cup
Evaporated milk	$\frac{1}{2}$ cup
Lemon extract or vanilla	1 teaspoonful

Boil squash until soft and peel. Mash until fine. Add the pili, sugar, milk and then cook. Stir continuously until fine and smooth. Remove from fire and add the flavoring.

Pili nut is also exported to Manila where it is made into confectioneries either for local consumption or for exportation to other countries.

According to the Commerce and Industry Journal for June, 1928 the pili has been exported to the United States, France, Great Britain, and Japan in varying quantities since 1913. This was the year when pili exportation was at its peak.

Compared with that for 1937, as may be seen from the following table, not to mention the meager exportations in the intervening years it is evident that there is room for considerable improvement:

	Kilos	Value
1913	1,186,173	₱188,270
1914	296,231	44,624
1915	145,150	23,576
1916	85,907	14,434
1917	2,153	1,058
1918	489	577
1919	13,254	3,923
1920	276	161
1921	121,549	17,949
1922	27,429	4,107
1923	38,808	4,010
1924	182	64
1925	7,433	427
1926	933	179
1927	22	37
1936	47,838	9,896
1937	63,800	23,009

The causes of the decline according to the same Journal are the following:

(1) High freight charges.
(2) Limited local supply.
(3) High local prices due to competition among local confectioners.
(4) Marketing of rotten nuts.
(5) Lack of device with which to effectively crack the nuts.
(6) Poor method of removing the pulp which, if allowed to stick too long, will hasten the deterioration of the kernels.

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ILLUSTRATIONS

PLATE 1

FIG. 1. A supposed late bearing pili tree, about 20 years old, at Sagrada, Buhi, Camarines Sur.
2. A nicely crowned pili tree at the edge of a fairly well cultivated abacá plantation at Agpay, Guinobatan, Albay.
3. Allegedly an ever-bearing pili tree, about 22 years old, at Buhi, Camarines Sur.
4. A pili tree, about 60 years old, used as abacá shade tree at Sorsogon.

PLATE 2

FIG. 1. An uncared for pili tree, about 70 years old, used as shade tree of an equally uncared for abacá plantation at Guinobatan, Albay.
2. A pili tree in a semi-wild state, about 70 years old, used as a shade tree of abacá plants in Albay. Note the climbing vines and other growing saprophytic plants.

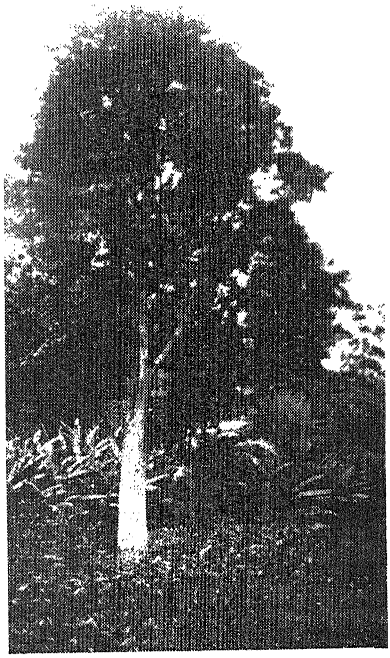
PLATE 3

FIG. 1. Pili trees in a semi-wild state at sitio Natubigan, Bo. Agpay, Guinobatan, Albay. Pili trees marked X.
2. Allegedly a thin-shelled pili nut bearing tree located at sitio Panal, Bo. Mapaco, Guinobatan, Albay. The tree is owned by Mr. G. Orbita of Mauraro, Guinobatan.
3. Pili trees as shade trees of an abacá plantation at sitio Natubigan, Agpay, Guinobatan, Albay. Note the other tree beside the mother plant, grown from a fallen (chance) nut from the latter. Many trees in the Bicol region are of such origin.

PLATE 4

FIG. 1. A luxuriant pili tree growing in between coconut trees.

1



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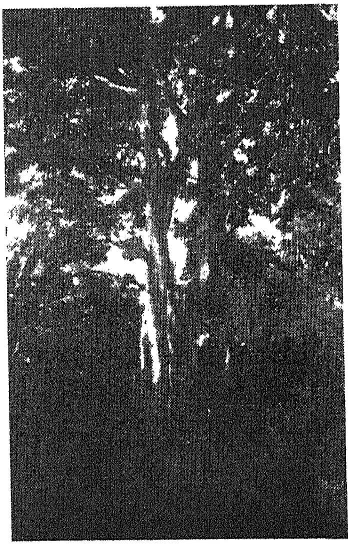

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PLATE 1.

1

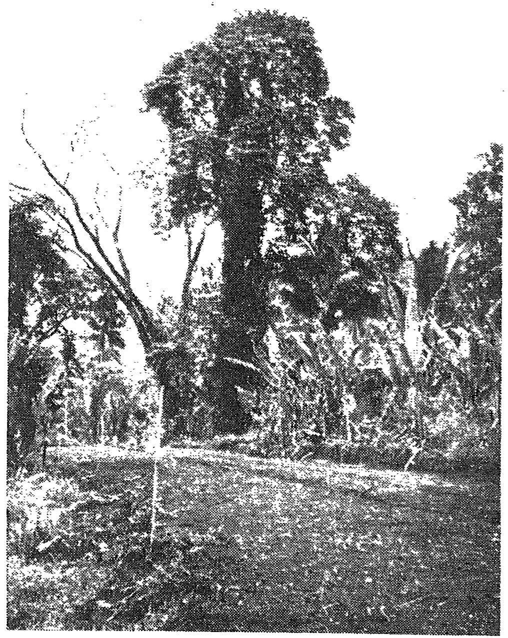

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PLATE 2.

1

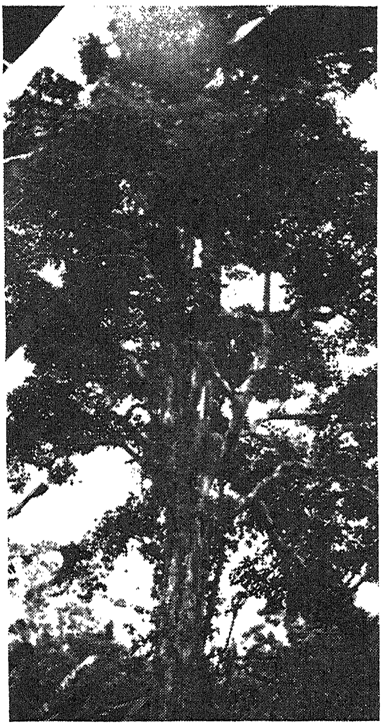

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PLATE 3.

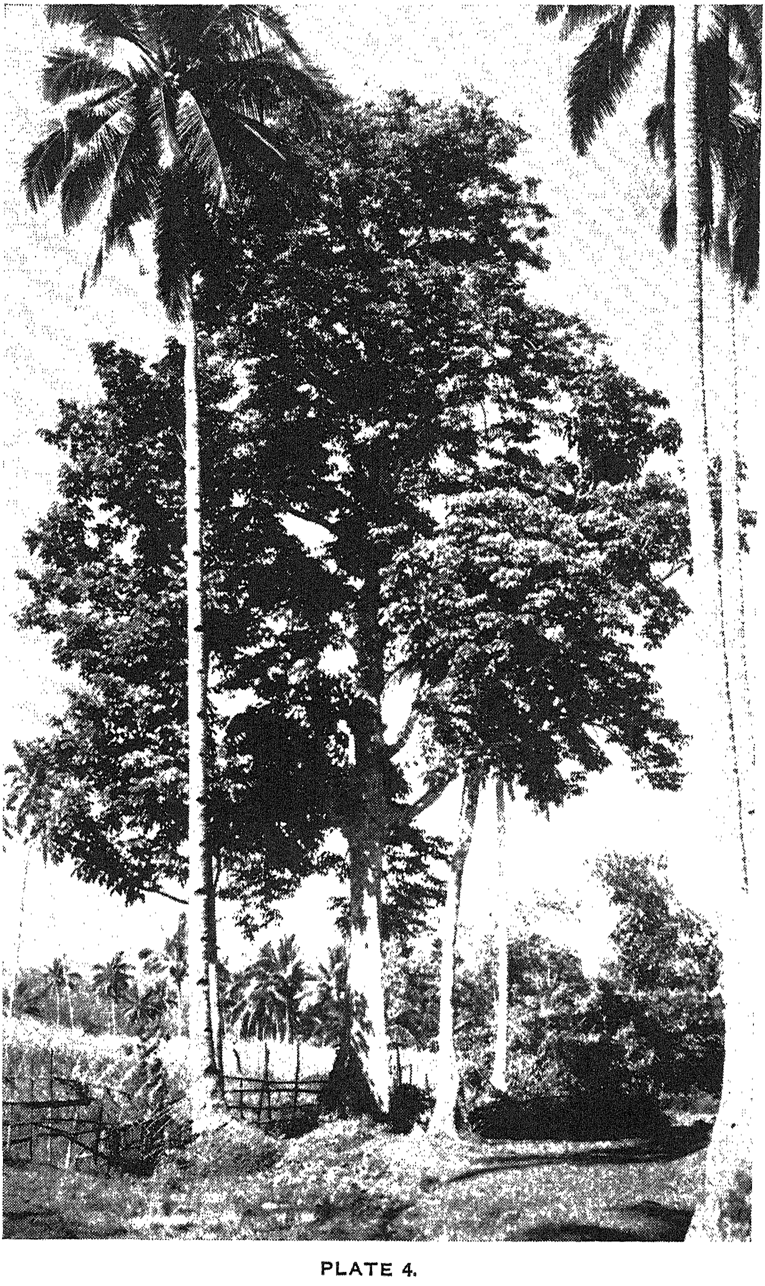

PLATE 4.

THE GRANJA SUGAR CANE EXPERIMENT STATION

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TWENTY-THREE PLATES

FOREWORD

The Granja Sugar Cane Experiment Station was the best developed and certainly the most profitable experiment station of the Bureau of Plant Industry. After 36 years of continuous operation under government management it passed hands last year (1938) to a new management, the Agricultural Service, Inc., (with head office at Manila) which acquired the station under a contract of lease. The operation of the station by the Government having been closed by virtue of this lease, an attempt is hereby made for purposes of record, to review brefly its past activities and salient accomplishments during the time it was run as a government institution. Institutions, like men, are judged by their achievements.

Using, therefore, a semblance of a yardstick to measure its accomplishments, the following questions present themselves: How far did the Granja approach the objectives for which it was established as an experiment station? What definite and tangible accomplishments has it contributed for the benefit of the farmers? What contribution did it make in the economic betterment of the country? Has it justified its existence as an experiment station for agricultural leadership?

The following paper, presented succinctly and as comprehensively as possible, is an honest and conservative appraisal of the work the Granja has done in attempting to answer the above questions, and can best be evaluated by the kind of contribution it has rendered in helping to improve Philippine agriculture.

HISTORY

The Granja Sugar Cane Experiment Station, known during the Spanish times as "La Granja Modelo" was established as a Spanish Garden by the Spanish Government about the year 1890.

The farm as such was kept in operation up to 1896. With the insurrection that year, it was taken over by the Negros Independent Government. In 1900 when the American Military authorities took charge of the Island of Negros, the farm passed hands again, this time as a military post known as Camp Barrett, during the Provisional Military Government. A portion of the station still retains the name Camp Barrett. In 1901 the farm was transferred to the Central Government and a year later (in 1902) it was turned over to the then newly established Insular Bureau of Agriculture for operation. The actual occupation of the farm under the new office began on April 22, 1903. At that time, the farm was in poor condition, the work having been abandoned during the insurrection. The remnants of the Spanish workings found in the place were a sugar mill, little plantings of coffee, cacao, abaca, beetlenuts, and farm implements and a few head of carabaos. The houses and growing crops were burned in 1899 by the Insurgents.

With the limited facilities found on the farm left out of the ruins of the revolution, work was resumed with attention directed in the main to sugar-cane culture, especially experiments and tests on the comparative merits of sugar-cane varieties. Fixing the premises in shape, clearing and transplanting the abandoned coffee, cacao, and abacá seedlings, trial plantings of seeds and plant materials sent by the Bureau to the station, erecting temporary quarters, building roads, and performing such other urgent and necessary work for its proper operation, all these were attended to. Thus, the work in the farm gradually picked up from year to year with semi-commercial production of sugar and the cultures of introduced cane varieties from abroad as the principal projects. In 1907 the commercial production of sugar cane was discontinued, only to be resumed in 1909; and during the suspension of commercial planting, the Bureau went into general experimental trials, and tests with sugar cane and other crops, such as abacá, maguey, corn, sweet potatoes, forage, and leguminous plants. At this time a number of mares, stallions, and Indian cattle were sent to the station with the idea of incorporating animal husbandry alongside the work of the station.

From 1910 on, the activities of the station in plant and livestock propagation and distribution not only gradually increased in volume but also gradually veered from experimental to commercial production.

In 1930, by virtue of Act No. 3639 splitting the Bureau of Agriculture into two bureaus, the Bureaus of Animal Industry and Plant Industry, the station land was divided accordingly, assigning to each Bureau its respective activities.

LAND

Location.—The Granja Sugar Cane Experiment Station is located at La Granja, La Carlota, Occidental Negros. La Granja is a barrio of La Carlota, 8 kilometers away from the town. It is about 54 kilometers from Bacolod and 33 kilometers from Pulupandan, the seaport of the province. The station is passed through by the La Carlota-La Castellana provincial road, a fact which renders it easily accessible by car and regular transportation facilities.

Area and its distribution.—The total area of this government land is 604.3124 hectares apportioned between two Bureaus as follows:

	Hectares
Granja Sugar Cane Experiment Station of the Bureau of Plant Industry	496.3124
La Carlota Stock Farm of the Bureau of Animal Industry	108.0000
Total	604.3124

The area of 496.3124 hectares belonging to the Granja Sugar Cane Experiment Station was, at the time the lease was effected, all under cultivation both by the administration and by its eight sugar-cane tenants as follows:

	Hectares
By the station:	
Field area for commercial plantings, experimental cultures, etc.	91.0000
Field area occupied by buildings, lawns, barrio obrero, nursery, orchards, pasture roads, building premises and other cultures	75.9124
School site	1.0000
By the sugar-cane tenants:	
Doroteo Jalandoni	56.0000
Luis Jalandoni	39.0000
Julia Managuit	48.8000
Rosa Jereza	6.6000
Santiago Maguad	25.0000
Baldomero Meana	72.0000
Manuel Gepanago	33.0000
Florencia Tad-Y	48.0000
Total	496.3124

Soil and climate.—The station is situated at the foot of Mount Kanlaon, with an altitude of about 107 meters above sea level. The general topography of the land is one which slopes gently from the east portion westward. The southwest portion of the entire reservation, however, is level with fertile, light loamy soil of volcanic origin. The depth of the surface soil varies from 30 centimeters to over 90 centimeters underlaid for the most part with drift boulders, gravel, and adobe rock. Because of its good topography, drainage is no problem. The general condition of the soil is excellent for all-round tropical agriculture.

The climate is also ideal for agriculture, the rainfall being fairly well distributed during the year. Usually the rain begins early in April and lasts till December. Dry months are January, February, and March but even in these months, there are occasional showers beneficial to the growing of annual and short growing crops.

This west Negros district is well beyond the typhoon belt and therefore, is free from the hazards of floods and destructive typhoons.

The rainfall and meteorological observation readings taken at the station in the last four years follow:

Year	Rainfall			Temperature C°			Relative humidity %		
	Number of rainy days	Average daily rainfall (inches)	Total (Inches)	Minimum (Average)	Maximum (Average)	Mean (Average)	Minimum (Average)	Maximum (Average)	Average
1935	120	0.268	72.69	16.2	37.4	22.0	53	86	75
1936	132	0.368	17.13	18.7	33.4	24.3	57	96	82
1937	147	0.336	9.79	20.5	33.2	26.5	57	96	82
1938	107	0.272	49.65	20.2	34.6	26.6	49	98	82

NOTE.—The 1935 record is for 9 months, that of 1938 is for 6 months, those of 1936 and 1937 are for all months except December.

Sugar quota of the government land.—With the advent of sugar limitation during the 1933–34 crop year the station's commercial sugar-cane area was allotted a quota of 14,134 piculs. Of this sugar quota, the station proper was allotted 4,228 piculs while the eight sugar-cane tenants of the station apportioned among themselves the rest or 9,906 piculs. The milling participation of the station and its tenants from the La Carlota Sugar Central is on the 55–45 basis; that is, 55 per cent for the station and 45 per cent for the Central. At this rate of participation (for the non-adhered planters as the station) and with the 12

per cent rate of rent derived from the tenants from their total quota paid to the Bureau, the station used to get annually the following sugar:

	Piculs
Exportable sugar	3,089.52
Local consumption sugar	266.82
Reserve sugar	157.89

ORGANIZATION AND PERSONNEL

The organization of the station literally bristles with varied reminiscences of both the Spanish, Negros Republic, and American régimes. Under the Spanish tutelage, the station was under the management of Don Jose Sanchez, a soil physicist. During the Negros Independent Government, the farm was managed by Mr. Francisco Perez, who was later relieved by Mr. Santiago Morales. When the military authorities took charge of Negros Island, Mr. Juan Araneta was appointed manager of the farm in representation of the United States Government, until it was transferred to the Central Government when Mr. A. P. Hyne, an American, was appointed as first Station Superintendent in 1902.

From that time on, in the lapse of 36 years, the station had the following superintendents:

Mr. A. P. Hyne	1902–1903
Mr. John Heil	1904–1905
Mr. H. J. Gallagher	1905–1908
Mr. F. E. Deason Mr. R. E. Burris	1909
Mr. H. J. Gallagher	1910–1914
Mr. J. McNamara	1915
Mr. M: Manas y Cruz	1916–1917
Mr. O. Soriano	1918
Mr. F. D. Marquez	1919–1923
Mr. S. Asuncion	1923–1926
Mr. A. Labrador Mr. P. A. Villyar (Acting)	1926–1927
Mr. F. D. Maramba	1928–1932
Mr. P. A. Honrado	1933–1934
Mr. J. B. Cabanos	1935–1938

Throughout all the years of operation of the station, these superintendents had their technical assistants and sufficient labor force to help them carry out the administration work and the tasks entailed by the different experimental and commercial projects of the station.

Tenants, tenancy, and population of the reservation.—In addition to the eight sugar-cane tenants of the station, there are small tenants on corn and rice living in the Government Reservation. The area cultivated by each family ranges from a hectare to two hectares. The rate of rental charged is from one-fourth to one-third of the crops depending on the fertility of the land. Aside from their activities as tenants of the station, they are now and then employed by the administration during busy days on the farm either on the basis of the piece work system, or the daily wage. It may be added in passing that the living conditions of the tenants of the station are comparatively more enhanced than the lot of the laborers and tenants in the average haciendas around La Granja.

A census of the population and other pertinent data of the station at the time the transfer was made are as follows:

	Barrios of—			Pasture lot converted for cultivation	Total
	La Granja	Pampang Suba	Pinamonan		
Area of homelots from 100 to 5,000 sq. m.	[a] 2.1075	[a] 1.2775	[a] 3.8025	[a] 0.5730	[a] 7.7605
Number of houses	39	19	32	9	99
Number of families	57	21	37	11	116
Population	283	94	151	44	574
Years of residence	[b] 1–35	[b] 6–20	[b] 1½–75	[b] 1–3	[b] 1–75
Station tenants	37	18	27	11	93
Station laborers	20	3	----------	1	24
Station laborers "Paquiao"	47	23	8	9	87
Rice and corn land cultivated	[a] 43.61	[a] 12.7	[a] 28.02	[a] 12.15	[a] 96.48

[a] Hectares. [b] Years.

ACTIVITIES AND ACCOMPLISHMENTS

A. Plant Industries

1. *Plant introductions, experiments, commercial planting, etc.*

(*a*) *Sugar cane.*—The Granja Sugar Cane Experiment Station was primarily established to serve the sugar industry of the Philippines. This station performed distinct service to the sugar industry as may be gleaned hereunder.

The work on introduction of sugar-cane varieties and their trials and tests at the station began in 1905. From time to time, thereafter, until 1930, many introductions and trial tests were made of such imported cane varieties as seemed desirable, from well-known sugar districts of the world at the station with a view to determining the best adapted varieties that would give

higher yields than those existing in the Philippines. In like manner, native varieties were tested with the idea of discarding those falling below standard.

The countries of origin, names, and years of introduction of these varieties are as follows:

P. I. number	Variety	Year introduced	Origin
8386	White Bamboo	1905	Hawaiian Sugar Planters' Association.
8769	Louisiana Purple	1905	Do.
4019	Demerara No. 74	1905	Do.
4020	Singapore Striped	1905	Do.
8753	Hawaii No. 16	1910	Do.
8754	Hawaii No. 20	1910	Do.
8755	Hawaii No. 27	1910	Do.
8756	Hawaii No. 69	1910	Do.
8758	Hawaii No. 227	1910	Do.
8759	Hawaii No. 309	1910	Do.
4019-A	Demerara No. 74	1910	Do.
4019-B	Demerara No. 117	1910	Do.
8748	Demerara No. 1135	1910	Do.
8751	H-109	1910	Do.
8770	Louisiana Striped	1911	Louisiana Sugar Experiment Station, U. S. A.
8812	Louisiana Purple	1911	Do.
8779	Yellow Caledonia	1911	Hawaiian Sugar Planters' Association.
4019-C	Demerara No. 74	1911	Louisiana Sugar Experiment Station, U. S. A.
8747	Demerara No. 95	1911	Do.
8764	Lahaina	1911	Honolulu, Hawaii.
8760	Cheribon Imperial Striped	1912	Australia.
8772	Malagache	1912	Do.
9850	Mauritius 1900	1912	Do.
8771	Malabar	1912	Do.
8811	White Bamboo	1912	Do.
8750	New Guinea No. 24	1912	Do.
8775	New Guinea No. 24-A	1912	Do.
8776	New Guinea No. 24-B	1912	Do.
8744	Barbados No. 3141	1912	Do.
8757	Hawaii No. 109	1912	Honolulu, Hawaii.
8763	Java 247	1912	Java.
10079	Chinois	1913	Saigon, Indo-China.
10078	Big Tanna	1913	Do.
8771	Malabar	1913	Australia.
8744	Barbados	1913	Do.
8752	Hambledon No. 5	1913	Do.
8777	New Guinea No. 40	1913	Do.
8775	New Guinea No. 24-A	1913	Do.
8776	New Guinea No. 24-B	1913	Do.
8743	Badila	1913	Do.
9328	P. O. J. 100	1915	Sugar Experiment Station, Pasoeroean, Java.
8603	P. O. J. 213	1915	Do.
4925	P. O. J. 2727	1915	Do.
4021	P. O. J. 826	1915	Do.

P. I. number	Variety	Year introduced	Origin
4022	P. O. J. 979	1915	Sugar Experiment Station, Pasoeroean, Java.
8746	Black Cheribon	1915	Do.
9323	P. O. J. 100	1916	Sugar Experiment Station, Pasoeroean, Java.
8817	P. O. J. 213	1916	Do.
4021 A	P. O. J. 826	1916	Do.
4022-A	P. O. J. 979	1916	Do.
4023	P. O. J. 1499	1916	Do.
4024	P. O. J. 1507	1916	Do.
4025	P. O. J. 2542	1916	Do.
9031	E. K. 2	1916	Do.
9032	D. I. 52	1916	Do.
4025	B 247	1916	Do.
8746-A	Black Cheribon	1916	Do.
4026	Java No. 36	1916	Formosa, Japan.
4027	Java No. 105	1916	Do.
8762	Java No. 213	1916	Do.
4028	Demerara No. 247	1917	Santiago Experiment Station, Cuba.
4029	Demerara No. 604	1917	Do.
4030	Demerara No. 625	1917	Do.
4031	Barbados No. 208	1917	Santiago Experiment Station, Cuba.
4032	Barbados No. 306	1917	Do.
4033	Barbados No. 1753	1917	Do.
4034	Barbados No. 3412	1917	Do.
4035	Barbados No. 6204	1917	Do.
4036	Barbados No. 6308	1917	Do.
4037	Barbados No. 6450	1917	Do.
4038	Lucier White	1917	Do.
10365	Barbados 147	1919	Proefstation, Pasoeroean, Java.
8546	Mia Lao	1924	Saigon, Indo-China.
9031	E. K. 2	1925	Pasoeroean, Java.
9032	D. I. 52	1925	Do.
9033	S. W. 3	1925	Do.
9090	B. H. 10/12	1925	San Juan, Porto Rico.
9171	Malayan Striped No. 7	1926	Kuala Lumpur, F. M. S.
9171-A	Malayan Striped No. 8	1926	Do.
9171-B	Malayan Striped No. 9	1926	Do.
9327	P. O. J. 36	1926	Pasoeroean, Java.
9328	P. O. J. 105	1926	Do.
9329	P. O. J. 213	1926	Do.
9330	P. O. J. 234	1926	Do.
9331	P. O. J. 279	1926	Do.
9332	Striped Preanger	1926	Do.
9472	CO. 205	1927	Pusa, Bihar, India.
9473	CO. 210	1927	Do.
9474	CO. 213	1927	Do.
9475	CO. 214	1927	Do.
9476	CO. 281	1927	Do.
4910	P. O. J. 2878	1927	Iloilo.
4926	P. O. J. 2883	1927	Do.
4924	Khari	1928	Java.
10366	DI 52	1928	Do.
9775	Khari	1928	South India.
9033	P. O. J.	1929	Pasoeroean, Java.
10408	Cross No. 1507	1931	Honolulu, Hawaii.

P. I. number	Variety	Year intro-duced	Origin
10409	B. H. 11569	1931	Honolulu, Hawaii.
10410	Pentwen	1931	Do.
10499	Mia Lao	1931	Saigon, Indo-China.
10500	Mia Lao Tiem	1931	Do.
12390	C. P. 27-108	1932	Florida, U. S. A.
12391	F-29-7	1932	Do.
11633	Mayaguez 42	1933	Washington, D. C., U. S. A.
11444	P. O. J. 2346	1933	Pasoeroean, Java.
11620	Mayaguez 3	1933	Washington, D. C., U. S. A.
11621	Mayaguez 7	1933	Do.
11443	P. O. J. 2725	1933	Pasoeroean, Java.
13185	P. O. J. 2961	1933	Do.
15320	P. O. J. 2961	1933	Do.

In the process of repeated trials and experimentations with these canes, the varieties which were found to be desirable were multiplied for distribution to the public. Other stations of the Bureau coöperated in the rapid propagation of recommended canes to supply the increasing demand for stock materials. The Granja Sugar Cane Experiment Station laid capital stress on the selection, propagation, and dissemination of the good varieties of sugar cane throughout the Philippines. For about 25 years, from 1905 to 1930, the station carried on the above activities, thus gradually eliminating the old, poor native canes by supplanting them with superior varieties. It is a matter of common knowledge among the sugar-cane planters that in the period from 1915 to 1930, such varieties as Hawaii Nos. 16, 20, 27, 69, 109 and others; the New Guinea, Nos. 15 (Badila), 24, 24–A, and 24–B; Barbados 147; Mauritius 1900; Java 247; Lahaina; Yellow Caledonia; the DI–52; Louisiana Striped; Negros Purple; Luzon White and Cebu Purple became very popular all over the Islands. Some of these varieties like the Badila, DI–52 and P. O. J. varieties maintained their popularity in Negros while the rest were either supplanted or replaced by new varieties like the Alunan and the P. S. A. 14.

In the distribution of cane cuttings and points secured from these good varieties, the records of the station from 1921 to 1938 are tabulated in Table 1 where it will be noted that the range of distribution was all over the sugar producing provinces of the Islands, and some foreign countries to which cuttings and points were sent in exchange.

TABLE No. 1.—*Showing the distribution of sugar cane points and cuttings at the Granja Sugar Cane Experiment Station from 1921 to 1938*

Varieties	Years					
	1921	1922	1923	1924	1925	1926
1. Badila	365	1,194	41,550	67,397	148,853	189,967
2. Barbados	228	337	900	3,142	7,600	75,670
3. Big Tana	370	233	800	2,625	700	100
4. Cebu Purple	154		5,510	5,100	9,503	18,000
5. Cheribon	17			10		
6. Chinois	102					
7. Demerara 95	6		300			
8. D-1135	1,203		2,000	100		
9. Formosa	3					
10. Guro or N. G.-24	537	120	5,400	11,946	2,550	36,550
11. Hambledon	3					
12. H-16	1,124					
13. H-20	725					
14. H-27	686	4	152			
15. H-227	1,528					
16. H-309	23					
17. Imperial Striped	3			6		
18. Ina Iman	333			3		2
19. Java-213	210	720				
20. Java-247	605	342	3,300	8,300	2,900	67,775
21. Lahaina	654					
22. Luzon No. 1	9	4	24	20	3	500
23. Luzon No. 2	187	276	1,002	3,700	3	1,505
24. Luzon No. 3	3	6	3,020	600		
25. Luzon No. 4	3	4	502			
26. H-109	2,000		9,700	11,515	13,600	59,700
27. Louisiana Purple	15			6		
28. Louisiana Striped	409	50	410	6,006	3,000	
29. Malabar	23	112	500			
30. Malagache	31			6		
31. Mindoro	2					
32. Negros Purple	326	1,032	15,600	54,645	23.003	119,025
33. New Guinea 24-A	3		2,200	10,596	16,425	97,314
34. New Guinea 24-B	154	176	2,500	8,445	3,475	28,425
35. Otomato	4					
36. Tigbao Mestiza	9					
37. Uba	9	7,094.4		10.200		
38. Yellow Caledonia	2,109	5,094	20,404	25,900	35.200	14,650
39. P. S. A. 14						
40. D1-52						
41. Rose Bamboo						7,000
42. P. O. J. 2878						
43. P. O. J. 2883						
44. P. B.-118						
45. Mauritius						
46. L. C. 28/1						
47. L. C. 22/4						2,715
48. L. C. 25/191 or Alunan						
49. L. C. 26/82						
50. L. C. 21/2						
51. L. C. 25/134						
52. L. C. 35/432						
53. L. C. 25/284						
54. L. C. 25/424						

TABLE No. 1.—*Showing the distribution of sugar cane, etc.*—Ctd.

Varieties	Years					
	1921	1922	1923	1924	1925	1926
55. L. C. 25/329						
56. L. C. 25/347						
57. L. C. 25/777						
58. L. C. 25/326						
59. L. C. 25/338						
60. L. C. 25/459						
61. H. Q. 429						
62. L. C. 25/229						
63. L. C. 25/210						
64. H. Q. 426						10
65. New Guinea-40	69	176		6		
66. B. H. Q. 10/12						
67. L. C. 20/422						
68. L. C. 25/224						
Totals	14,244	16,974	115,778	230,274	226,815	718,908

Varieties	Years					
	1927	1928	1929	1930	1931	1932
1. Badila	136,980	78,600	32,015	2,496		
2. Barbados	24,470	26,154	1,000			
3. Big Tana						
4. Cebu Purple	2,000	1,000				
5. Cheribon						
6. Chinois						
7. Demerara 95						
8. D-1135	50	12				
9. Formosa						
10. Guro or N. G.-24	25,677	4,034				
11. Hambledon		34,700	5,083			
12. H-16		5				
13. H-20		5				
14. H-27		5				
15. H-227						
16. H-309		5				
17. Imperial Striped						
18. Ina Iman						
19. Java-213	102					
20. Java-247	25,225	29,580	11,640	1,000		
21. Lahaina						
22. Luzon No. 1	1,000	400				
23. Luzon No. 2						
24. Luzon No. 3						
25. Luzon No. 4						
26. H-109	108,910	18,312	16,060	200		
27. Louisiana Purple	3,507					
28. Louisiana Striped		2,600				
29. Malabar						
30. Malagache	2					
31. Mindoro						
32. Negros Purple		450	3,500			
33. New Guinea 24-A	372,789	67,350	17,484	2,046		
34. New Guinea 24-B	13,727	15,700				
35. Otomato						

TABLE NO. 1.—*Showing the distribution of sugar cane, etc.*—Ctd.

Varieties	Years					
	1927	1928	1929	1930	1931	1932
36. Tigbao Mestiza						
37. Uba	5,800					
38. Yellow Caledonia	44,380	13,590	500			
39. P. S. A. 14						
40. D1-52		53	4,716	262		
41. Rose Bamboo	16,900	4,400	50			
42. P. O. J. 2878	6	34	308	981		
43. P. O. J. 2883						
44. P. B.-118		10				
45. Mauritius	2	500	10			
46. L. C. 28/1			10	10		
47. L. C. 22/4	12,887	5,857	9,800	12		
48. L. C. 25/191 or Alunan	5,000	80,000	172,244	329,321	914,100	285,600
49. L. C. 26/82			8	10		
50. L. C. 21/2	10			10		
51. L. C. 25/134	10					
52. L. C. 35/432		10				
53. L. C. 25/284	6					
54. L. C. 25/424	12					
55. L. C. 25/329	11					
56. L. C. 25/347	6					
57. L. C. 25/777	23					
58. L. C. 25/326	54					
59. L. C. 25/338	5					
60. L. C. 25/459	12					
61. H. Q. 429	3,052	1,000	1,026	10		
62. L. C. 25/229		25				
63. L. C. 25/210		20				
64. H. Q. 426	48,709	12,027	600			
65. New Guinea-40						
66. B. H. Q. 10/12			10			
67. L. C. 20/422			10			
68. L. C. 25/224			70			
Totals	851,324	396,438	276,324	336,358	914,100	285,600

Varieties	Years					
	1933	1934	1935	1936	1937	1938
1. Badila					48,400	6
2. Barbados					25	6
3. Big Tana						
4. Cebu Purple						
5. Cheribon						
6. Chinois						
7. Demerara 95						
8. D-1135						
9. Formosa						
10. Guro or N. G.-24						
11. Hambledon						
12. H-16						
13. H-20						
14. H-27						
15. H-227						

TABLE No. 1.—*Showing the distribution of sugar cane, etc.*—Ctd.

Varieties	Years					
	1933	1934	1935	1936	1937	1938
16. H-309						
17. Imperial Striped						
18. Ina Iman						
19. Java-213						
20. Java-247					6	
21. Lahaina						
22. Luzon No. 1						
23. Luzon No. 2						
24. Luzon No. 3						
25. Luzon No. 4						
26. H-109						
27. Louisiana Purple						
28. Louisiana Striped						
29. Malabar						
30. Malagache						
31. Mindoro						
32. Negros Purple						
33. New Guinea 24-A						
34. New Guinea 24-B						
35. Otomato						
36. Tigbao Mestiza						
37. Uba						
38. Yellow Caledonia						
39. P. S. A. 14					20,000	6
40. D1-52					700	6
41. Rose Bamboo						
42. P. O. J. 2878						
43. P. O. J. 2883					24	6
44. P. B.-118						
45. Mauritius						
46. L. C. 28/1						
47. L. C. 22/4						
48. L. C. 25/191 or Alunan	168,900	483,000	5,000	594,000	402,100	400
49. L. C. 26/82						
50. L. C. 21/2						
51. L. C. 25/134						
52. L. C. 35/432						
53. L. C. 25/284						
54. L. C. 25/424						
55. L. C. 25/329						
56. L. C. 25/347						
57. L. C. 25/777						
58. L. C. 25/326						
59. L. C. 25/338						
60. L. C. 25/459						
61. H. Q. 429						
62. L. C. 25/229						
63. L. C. 25/210						
64. H. Q. 426						
65. New Guinea-40						
66. B. H. Q. 10/12						
67. L. C. 20/422						
68. L. C. 25/224						
Totals	168,900	483,000	5,000	594,000	471,471	340

NOTE:

Distributed to 138 parties (in 1921 at Central Office) in Pampanga, Laguna, Batangas, Occidental Negros, Australia, Argentine Republic, Japan, and Nueva Ecija.

Distributed to 34 parties (in 1922 at Central Office) in Pampanga, Nueva Ecija, Laguna, Occidental Negros, and Brisbane, Australia.

Distributed to 179 parties (in 1923 at Central Office) in Pampanga, Laguna, Batangas, Tarlac, Nueva Ecija, Occidental Negros, Oriental Negros, Iloilo, Isabela and Ilocos.

Distributed to 221 parties (in 1924 at Central Office) in Pampanga, Laguna, Batangas, Tarlac, Nueva Ecija, Occidental Negros, Oriental Negros, Iloilo, Isabela, Japan, Argentine Republic, Australia and Ilocos.

Distributed to 193 parties (in 1925 at Central Office) in Pampanga, Laguna, Batangas, Tarlac, Nueva Ecija, Occidental Negros, Oriental Negros, Iloilo, Isabela, and Australia.

Distributed to 488 parties (in 1926 at Central Office) in Pampanga, Laguna, Batangas, Tarlac, Nueva Ecija, Occidental Negros, Oriental Negros, Iloilo and Australia.

Distributed to 550 parties (in 1927 at Central Office) in Pampanga, Laguna, Batangas, Tarlac, Nueva Ecija, Occidental Negros, Oriental Negros, Iloilo, Isabela, Ilocos, Bulacan, Rizal, Australia and Japan.

Distributed to 385 parties (in 1928 at Central Office) in Pampanga, Laguna, Batangas, Tarlac, Nueva Ecija, Occidental Negros, Oriental Negros and Iloilo.

Distributed to 388 parties (in 1929 at Central Office) in Pampanga, Laguna, Batangas, Tarlac, Nueva Ecija, Occidental Negros, Oriental Negros, Iloilo, Australia and Ilocos.

Distributed to 66 parties (in 1930 at Central Office) in Pampanga, Laguna, Occidental Negros, Iloilo and Rizal.

Distributed to 12 parties (in 1937 at Central Office) in Occidental Negros and Lanao.

Distributed to 3 parties in 1938 in Oriental Negros, Romblon and Hawaii.

The data on the distributions of the Alunan cane from 1931 to and including 1936, were taken from the article entitled "The Alunan Cane", by "Lanuza and Cruz", Phil. Agri. Rev., Vol. 8, No. 3, 1937, page 314.

Aside from the sugar-cane variety and acclimatization tests the important tests were those on the uses of fertilizers, milling, distance of planting, irrigation, deep versus shallow plowing, hilling, trash thinning versus burning, double versus single points planting, and non-defoliation. Studies on pests and diseases and other cultural and crop rotation experiments were also conducted.

Results derived from these experimentations were extended to sugar planters by demonstration, coöperative work, and other allied extension activities.

The benefits derived from these experiments and extension activities may be summarized by saying that the variety tests and analyses of varieties made possible the elimination of undesirable varieties; the milling tests, the improved manufacture of sugar; the extension work in the propagation of the best cane varieties, better cultural methods, and more effective control of pests and diseases. All these results were instrumental in safeguarding the investment of money and making the sugar business highly profitable.

Mention is also made here of the sugar laboratory work of the station the services of which farmers of the district availed themselves of free of charge. Before the milling season the

station received samples of their canes for analysis. This work was popular among the planters as the analyses made of the canes determined the right milling time.

An important phase of the sugar-cane work of the station was cane breeding. The cane hybridization work had many objects aimed at but the most important was the production of strains superior to the then existing varieties. The first attempt at hybridization was made during the 1921–1922 sugar-cane season. Yearly crosses were made thereafter but the last batch of seedlings trace their origin from the 1931 and 1932 crops.

Records of the station show that thousands and thousands of seedlings were produced, cultured, and studied but only one seedling strain from the cross between the New Guinea No. 15 (Badila) and the Java 247 stood the rigid test of selection. This strain is now called the famous L. C. 25/191 or the Alunan cane[1], a distinct and valuable contribution of the Granja Sugar Cane Experiment Station to the sugar industry, produced by the late Anselmo Labrador and named in honor of the then Secretary of Agriculture and Natural Resources, Hon. Rafael R. Alunan, one of those preeminently connected with the sugar industry.[2]

The station had under culture at the time it was turned over to Agricultural Service, Inc., seedling canes of the varieties enumerated in Table 2. These seedlings came from the 1931 and 1932 crosses, with the exception of L. C. 25/190, L. C. 25/130, and L. C. 30/100 which were from the 1925 and 1930 crosses. A number of these seedlings (see Table 2) are of great promise, especially the following:

L. C. 25/190	L. C. 30/100
L. C. 25/310	L. C. 31/14
L. C. 31/530	L. C. 31/1551
L. C. 31/265	L. C. 31/20
L. C. 31/13	L. C. 31/1521
L. C. 31/1460	L. C. 31/262
L. C. 31/263	L. C. 31/347
L. C. 31/1501	L. C. 31/1398

After a series of strain tests made of these hybrid seedlings, it was found that L. C. 25/190, another selection from the cross

[1] See Lanuza and Manas Cruz. The Alunan Cane in the Sugar Industry of Negros. Phil. Journal of Agri., Vol. 8 (1937), pp. 311–325.

[2] L. C. stands for La Carlota; figure *25* stands for 1925, the year when the cross was made; 191 stands for the serial number of the seedling.

between Java 247 and Badila which gave rise to the well-known Alunan, and L. C. 30/100 seedlings from the cross between P. O. J. 2878 and P. B. 119 are as good as the Alunan itself. To differentiate these strains from the Alunan, or other cane varieties, I propose to name the L. C. 25/190 strain as the "Labrador" cane as posthumous honor to its originator and the L. C. 30/100 strain as the "La Granja" cane in honor of the station, for its pioneering leadership in the promotion of the Philippine sugar industry and as a fitting memento of the meaning of its name aptly given by the Spaniards and which it maintained during the 48 years of its operation as a government institution.

TABLE No. 2.—*Seedling canes at Granja Sugar Cane Experiment Station under 1938 culture.*

Variety or strain No.	Parentage ♀ x ♂	Analysis			
		1935-36 crop		1936-37 crop	
		Suc. (11	P-T mos.)	Suc. (10	P-T mos.)
L. C. 31/14	DI-52 x Bukidnon	18.84	2.26	15.96	1.92
L. C. 31/530	H-109 x LCTR	19.20	2.21	14.68	1.65
L. C. 31/766	H-109 x LCTR	—	—	—	—
L. C. 31/563	do	—	—	19.85	—
L. C. 31/1551	LC 25/191 x Barbados 147	19.32	2.35	16.75	2.04
L. C. 31/265	H-109 x LCTR	19.54	2.18	16.58	1.92
L. C. 31/225	POJ 2883 x LCTW	—	—	—	—
L. C. 31/20	DI-52 x Bukidnon Tig	17.23	2.27	15.77	1.83
L. C. 31/13	do	17.99	2.21	16.03	1.97
L. C. 31/800	H-109 x LCTR	—	—	—	—
L. C. 31/296	do	12.79	1.34	14.86	1.72
L. C. 31/3	DI-52 x Bukidnon	16.46	1.94	13.78	1.60
L. C. 31/672	H-109 x LCTR	15.74	1.81	16.26	1.95
L. C. 31/1521	B. 147 x Badila	16.25	1.93	16.59	1.92
L. C. 31/1460	Badila x Barbados 147	14.62	1.62	15.59	1.98
L. C. 31/327	DI-52 x LCTW	17.89	2.18	15.21	1.76
L. C. 31/262	do	19.15	2.27	17.06	2.16
L. C. 31/263	do	20.58	2.59	19.21	2.40
L. C. 31/347	Badila x Barbados 147	19.56	2.09	19.31	2.39
L. C. 31/1421	do	18.85	2.29	13.20	1.47
L. C. 31/1103	Barbados 147 x LCTY	17.73	2.05	16.19	1.85
L. C. 31/1501	Barbados 147 x Badila	19.26	2.38	19.22	2.36
L. C. 31/1483	do	19.17	2.14	16.77	1.87
L. C. 31/1398	Barbados 147 x LCTY	16.68	1.87	17.47	2.11
L. C. 31/13	DI-52 x Bukidnon	17.95	2.01	17.41	2.09
L. C. 31/1621	Java 247 x LCTR	14.80	1.61	14.10	1.56
L. C. 31/1130	Badila x Barbados 147	16.86	1.92	14.56	1.66
L. C. 31/100	POJ 2878 x PB 119	15.49	1.55	18.92	2.31
L. C. 31/190	J. 247 x Badila	15.69	1.66	18.44	2.27
L. C. 31/73	POJ 2882 x LCTW	—	—	15.64	—
L. C. 31/535	H-109 x LCTR	—	—	17.35	—
L. C. 31/1158	do	—	—	—	—
L. C. 31/306	DI-52 x LCTW	—	—	14.09	—
L. C. 31/249	N. Purple x LCTW	—	—	17.34	—

NOTE:

LCTR—La Carlota Tigbao Red.
LCTW—La Carlota Tigbao White.
LCTY—La Carlota Tigbao Yellow.

TABLE NO. 2.—*Seedling canes at Granja Sugar Cane Experiment Station under 1938 culture.*—Continued

Variety or strain No.	Parentage ♀ x ♂	Analysis			
		1935-36 crop		1936-37 crop	
		Suc. (11	P-T mos.)	Suc. (10	P-T mos.)
L. C. 31/355	DI-52 x Encar				
L. C. 31/310	DI-52 x LCTW				
L. C. 31/18	DI-52 x Bukidnon				
L. C. 31/1479	Badila x POJ 2878				
L. C. 31/1321	POJ 2878 x LCTW				
L. C. 31/1440	Badila x Barbados 147				
L. C. 31/1419	Barbados 147 x LCTY				
L. C. 31/615	H-109 x LCTR				
L. C. 31/383	do				
L. C. 31/1384	Barbados 147 x LCTY				
L. C. 31/302	DI-52 x LCTW				
L. C. 31/337	DI-52 x Encar				
L. C. 31/387	H-109 x LCTR				
L. C. 31/272	DI-52 x LCTW				
L. C. 31/319	do				
L. C. 31/314	H-109 x LCTR				
L. C. 31/138	POJ 2883 x LCTW				
L. C. 31/1573	Barbados 147 x LC 25/191				
L. C. 31/1402	Barbados 147 x LCTY				
L. C. 31/1557	LC 25/191 x Barbados 147				
L. C. 31/ 140	POJ 2883 x LCTW				
L. C. 31/1372	Badila x Barbados 147				
L. C. 31/1387	Barbados 147 x LCTY				
L. C. 31/1401	do				
L. C. 31/1157	H-109 x LCTR				
L. C. 31/928	do				
L. C. 31/1385	Barbados 147 x LCTY				
L. C. 25/310	J. 247 x Badila				
L. C. 32	Parentage unknown				
L. C. 32	do			17.46	
L. C. 32	do			16.45	
L. C. 32	do			15.77	
L. C. 32	do			21.05	
L. C. 32	do			17.85	
L. C. 32	do			18.84	
L. C. 32	do			19.79	
L. C. 32	do				
L. C. 32	do			13.96	
L. C. 32	do			17.97	
L. C. 32	do			18.06	

NOTE:

LCTW—La Carlota Tigbao White.
LCTY—La Carlota Tigbao Yellow.
LCTR—La Carlota Tigbao Red.
H109—Hawaii 109.
Encar—Encarnacion.
25, 30, 31, 32 —Represent years 1925, 1930, 1931 and 1932.
LC.—La Carlota.

With respect to its popularity among the planters, its rapid rise as a standard variety, its performance, etc., Dr. Alexander Gordon, chief of the department of agriculture and experiments of the La Carlota Sugar Central, has the following to say of the Alunan cane in his Seventh Annual Report as of June 30, 1938:

ALUNAN (L. C. 25/191), LA CARLOTA DISTRICT STANDARD CANE

The Alunan (L. C. 25/191) has now become our standard variety for this district. This is a signal success for the late Anselmo Labrador, plant breeder of the Granja Sugar Cane Experiment Station of the Bureau of Plant Industry.

As intimated early in 1935 (see Fourth Annual Report of this Department, April 16, 1935) Alunan (L. C. 25/191) is the standard crop of this district. At present (1938–39 crop) Alunan is grown in over 50 per cent of the La Carlota district cane area. The Badila which has been our standard cane for so long is now being left out. The P. O. J. 2878 which was at one time the craze of the district is now almost forgotten.

This favorite variety (Alunan) is the cause of high yields in this district. Henceforth, we shall take the Alunan for our standard cane.

The following Table 3, culled from the records of the Agricultural Department of the La Carlota Sugar Central before the lease of the station was effected, indicates the percentage of areas planted to the different cane varieties in that district:

TABLE 3.—*Showing the percentage of areas planted to different varieties during the last nine crop years at the La Carlota Sugar Central District.*

Variety	1930 to 1931	1931 to 1932	1932 to 1933	1933 to 1934	1934 to 1935	1935 to 1936	1936 to 1937	1937 to 1938	1938 to 1939
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Alunan (LC 25/191)[1]	-------	-------	0.97	2.83	7.23	15.00	20.00	34.49	50.93
Badila	30.94	38.98	37.81	43.95	44.70	40.00	40.00	31.28	28.85
P. O. J. 2883	-------	0.09	0.36	1.67	3.30	8.00	10.00	9.95	11.60
D. I. 52	1.37	3.00	3.50	4.26	5.65	5.00	4.00	5.04	7.25
P. O. J. 2878	0.99	7.10	16.41	24.92	19.04	25.00	20.00	1.86	1.23
New Guinea 24-A	4.42	8.27	7.90	5.00	3.90	1.00	1.00	0.46	0.14
Negros Purple	61.01	41.22	19.35	11.58	4.33	2.00	2.00	0.15	-------
All Others	1.27	1.34	13.70	5.79	11.85	4.00	3.00	16.77	-------

[1] The 1938–39 crop of the district is about 12,000 ha. Note the growing area planted to the Alunan cane.

The foregoing table is an up-to-date record of the plantings in the district as it includes the present crop of the 1938-39 cane-crop year. The rapid increase in the area planted to the cane within the last six crop-years speaks highly of the superiority of the variety over the other varieties of the district.

Graphs I, II, and III show the volume of the Alunan cane that was milled in the same Central during the 1937–38 crop-year

compared with other varieties in the district, and the yearly increase in tonnage of the Alunan cane milled by the Central during the 1932–33 to 1937–38 crop-years.

Regarding the total area covered by the Alunan cane in Occidental Negros, Table 4 gives 10,368.28 hectares for the 1937–38 cane crop. This figure has been arrived at after a thorough central to central checking conducted by the Twelfth Agronomical District.

TABLE 4.—*Showing the total area planted to the different varieties of sugar cane in the different mill districts of Occidental Negros during the crop year 1937–38.*

Centrals	P. O. J. 2878	P. O. J. 2883	D. I. 52	Badila
	Hectares	*Hectares*	*Hectares*	*Hectares*
Bacolod-Murcia	3,029.27	272.96	477.75	3,136.42
Bearing	1,618.40	161.84	20.23	40.46
Binalbagan	1,626.00	1,988.20	132.38	2,070.28
Danao	1,330.50			
Hawaiian-Philippine	1,387.86	714.96	845.02	3,674.47
Isabela	900.00	300.00	800.00	1,200.00
La Carlota [2]	183.75	986.04	499.44	3,098.43
Leonor	524.00	65.00		641.00
Lopez	1.341.83	181.44		544.48
Ma-ao	729.57	875.48	1,695.06	1,823.94
Manapla	5,182.13	1,652.73	76.36	2,040.58
Palma	261.00	870.00		174.00
San Carlos [1]	3,864.23			
San Isidro	528.00	452.00		151.00
Santa Aniceta		123.41	569.14	126.34
Talisay-Silay	2,432.06	875.91	1,804.75	934.75
Victorias	1,427.31	3,823.20	62.51	1,303.75
Totals	26,338.91	13,343.17	6,982.64	20,959.90

Centrals	L. C. 25/191	New Guinea	Negros Purple	Luzon White	H—109
	Hectares	*Hectares*	*Hectares*	*Hectares*	*Hectares*
Bacolod-Murcia	552.15	45.24	478.45		23.92
Bearing	131.38				
Binalbagan	697.25				
Danao					
Hawaiian-Philippine	750.00		45.95		
Isabela	757.00		480.00	20.00	
La Carlota [2]	3,416.54	45.67	14.43		
Leonor					
Lopez	152.23				
Ma-ao	1,021.40	291.83	656.63	72.96	
Manapla	1,140.58		14.02		64.93
Palma	348.00				
San Carlos [1]	33.03				
San Isidro	301.00				
Santa Aniceta	2.62		22.89		
Talisay-Silay	693.04		353.26		
Victorias	372.04	6.08	26.07		
Totals	10,368.26	388.82	2,091.70	92.96	88.85

[1] Sugar cane grown at Valle Hermoso, Oriental Negros is milled at Central San Carlos.

[2] Records of the Central for the 1938–39 crop show that Alunan cane occupies about 6,000 ha.

TABLE 4.—*Showing the total area planted, etc.*—Continued.

Centrals	Mauritius	P. S. A. 14	Hambledon	Other varieties	Total area
	Hectares	*Hectares*	*Hectares*	*Hectares*	*Hectares*
Bacolod-Murcia					
Bearing				60.69	
Binalbagan	1.85				
Danao				23.00	
Hawaiian-Philippine				369.94	
Isabela				84.00	
La Carlota [2]				1,661.69	
Leonor				35.00	
Lopez		105.66		370.80	
Ma-ao			218.87		
Manapla				203.95	
Palma				87.00	
San Carlos [1]					
San Isidro				75.00	
Santa Aniceta					
Talisay-Silay					
Victorias				472.93	
Totals	1.85	105.66	218.87	3,344.00	84,325.59

[1] Sugar cane grown at Valle Hermoso, Oriental Negros is milled at Central San Carlos.
[2] Records of the Central for the 1938–39 crop show that Alunan cane occupies about 6,000 ha.

With respect to the production of the Alunan cane, both in tonnage and in piculs per hectare, Table No. 5 gives the results of the 1937–1938 commercial cane planting of the Granja Sugar Cane Experiment Station in its rôle as one of the planters of the La Carlota Mill District.

TABLE 5.—*Showing the production of the Alunan Sugar Cane as compared with that of other varieties in the 1937–38 commercial cane planting of the Granja Sugar Cane Experiment Station.*

Variety	Area hectare	Kind of crop	Production				
			Total tons cane	Total piculs sugar	Tonnage per hectare	Piculs per hectare	P/T
Alunan (L. C. 25/191).	10.97	Plant cane	1,263.90	2,130.59	115.22	194.22	1.685
Do	8.46	Ratoon	530.30	1,120.99	62.68	132.50	2.113
Badila	2.39	Plant cane	178.90	287.44	74.85	120.27	1.607
Do	4.39	Ratoon	285.10	532.55	64.94	121.31	1.868
DI-52	0.26	Plant and ratoon	14.81	24.57	[a] 56.96	[a] 94.50	1.659
PSA-14	0.45	Plant cane	29.00	49.57	[a] 64.44	[a] 110.16	1.711

[a] Estimated production per Ha.
NOTE.—Milled from 26.92 hectares to cover the station quota of 4,228 piculs.

The results as shown in Table 5 indisputably establish the superiority of the Alunan cane over all other varieties in both cane tonnage and in piculs of sugar. These results, too, are in

accord with the general production obtained in Negros for the different cane varieties whereby the Alunan averages 140 to 145 piculs while the other next leading varieties like the P. O. J. 2878 and the Badila, average 125 to 130 piculs per hectare. Figuring the extra worth of the variety in terms of cash returns to the industry, with the crop just milled (1937–1938) when 10,368.26 hectares in the entire province were planted to the Alunan cane, a difference of 15 piculs per hectare stands in favor of the Alunan cane. This difference of 15 piculs multiplied by 10,368.26 hectares gives 155,523.9 piculs. At ₱7 per picul, the 1938 market quotation for sugar, it gives the astonishing figure of ₱1,088,667.30 extra money accruing to the Negros planters without utilizing additional areas or incurring extra expenses. This is a worthy accomplishment of the Granja Sugar Cane Experiment Station. In lowering the cost of production of Philippine sugar to enable the industry to withstand stiff world competition when the preferential tariff enjoyed by our sugar in the United States is gradually withdrawn, we have in the high yielding Alunan cane a major contribution to the crying need of present day Philippine export crops, i. e., lower cost of production.

The Alunan cane is as yet the fourth ranking variety in hectarage in the whole Negros but for the present crop (1938–1939) it tops the P. O. J. 2883 and follows closely the Badila. The La Carlota mill district alone, the district with the biggest quota planted over 6,000 hectares to the Alunan cane last season out of its total hectarage of about 12,000 hectares. (See Tables 3 and 4).

In brief, to evaluate the present worth of the variety in terms of pesos, using the preceding figures as a basis, the Alunan is now a ten-million-peso sugar-cane variety.

The future of the Alunan cane is fraught with great possibilities, based upon its meteoric ascendancy in so short a period of six crop-years. It bids fair to play an important rôle in the reckoning of Philippine sugar.

WORK ON MISCELLANEOUS AGRONOMY AND HORTICULTURAL CROPS

1. While the chief work of the station, for many years, was on sugar for the benefit of the sugar industry, impending economic readjustment and changing agricultural conditions of the Philippines in recent years demanded a reorientation and pointed to the danger of one crop specialization as in the case

of sugar in Negros. The station, in anticipation of the adverse future looming ahead of the sugar industry in view of the sugar limitation, accordingly directed its activities in the main towards the launching of a long-range crop diversification program for the province. The station was thus called upon to study crop substitutes and their relative adaptability and to produce and distribute suitable varieties of planting materials. It had to adhere closely to this program in order to help bring about the desirable agricultural adjustment.

The work of the station on miscellaneous field crops was invaluable to the farmers in guiding them properly as to the most feasible means of utilizing large areas released from sugar cane, which otherwise would lie idle. The miscellaneous field crops advocated and produced by the station for the farmers in this crop diversification program are as follows:

(*a*) *Rice and corn.*—The station produced on a commercial scale for distribution to farmers selected and improved seeds of good varieties of corn and rice, such as F1 seeds of the Calamba Yellow and the Cebu corn, and seeds of the standard upland rice like the Dumali, Inantipolo, Kinastila, Magsanaya, and others. These are being planted on an extensive commercial scale by Occidental Negros farmers among whom are Messrs. Alfredo Montelibano and Fernando Arguelles of Murcia at Haciendas Binitin and Caliban, respectively; Jose Fuentebella and Antonio Gonzaga of Bacolod; Guillermo Presbitero of Valladolid; and the owners of Haciendas Boyog and Carminia, Escalante and a number of nearby haciendas in the La Carlota mill district.

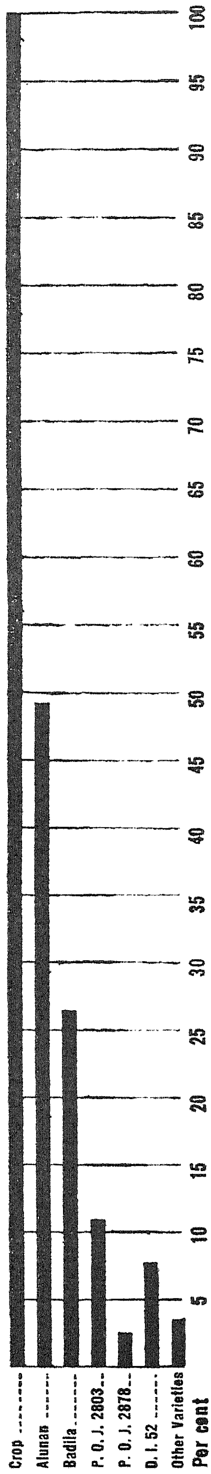
Negros is gradually becoming an important upland rice and corn growing province. The initial interest shown by the farmers to the growing of these crops may be directly attributed to the promotion work of the station in this regard.

(*b*) *Root crops.*—Root crops, like the standard varieties of cassava, peanuts, gabi, ubi, arrowroot, camote, and other crops, were also planted in order to supply planting materials to the people. These crops are highly adapted to the soil and climatic conditions obtaining in Negros and fit very well into the scheme of crop diversification for the province. While cassava and peanuts, by reason of their bigger commercial possibilities, are most in demand, still the interest in camote, gabi, ubi, ginger, and other crops, was appreciable enough to warrant their being

allowed substantial berth in the crop diversification scheme for the Province of Negros.

Cassava as a commercial crop of the province has very bright prospects not only because of the favorable climate and soil but also because of the availability of ready capital and excess machine power in the different sugar centrals that could be readily utilized in the industrialization of the same. To be sure, plans are now afoot by some big planters in some of the mill districts to put up cassava factories either under the centrals' management as in the case of sugar cane or as separate plants solely devoted for the purpose. The big cassava planters of the province are: Don Gil Lopez, Dr. Doroteo Cabayao, and Dr. Elias H. Pañganiban of Faraon, Cadiz. Dr. Gil Lopez has a cassava factory which was established in 1936 in coöperation with the station. The station was instrumental in enlisting the interest of the public in the planting of this profitable crop.

(c) *Fiber and oil crops.*—The fiber and oil crop projects of the station date back as early as 1905 and were continued in operation up to about 1920 when these activities were transferred to other stations of the Bureau so that as much attention as possible could be devoted to sugar cane. Varieties of fiber and oil crops were cultured, among which were abacá, sisal, maguey, kapok, ramie, panama palm and jute; castor oil, and other oil plants. Results of studies and experiments conducted in this direction formed the basis of information of the Bureau on these crops. In later years the silkworm and the African oil palm cultures were undertaken for adaptability trials. When the abacá project was started some districts were planted to the crop but with the craze for sugar cane planting gullies and



GRAPH I.—Comparing the Alunan cane with other varieties in percentage of cane milled at the La Carlota Sugar Central (from the Central's records) Crop year 1937–38.

foot hills which were suitable for abacá culture were in turn cleared and converted into sugar-cane areas. Some abacá varieties are still extant in limited areas at the foot of mountains at La Castellana, Isabela, Murcia, Manapla, and Cadiz and their origin can be traced to the abacá project of the station. Abacá, while a minor crop of Negros, fills in an important domestic need considering that the province is highly agricultural.

(*d*) *Derris.*—The derris project was started by the station in 1935 as one of the replacement crops occasioned by the sugar limitation. During these last 3 years derris has elicited great interest on the part of the planters. In anticipation of a large demand for planting materials, the station took the lead in propagating the plant on a big scale. Selected plants ranging from 4 to 8 per cent in rotenone content gathered by the personnel of the station in their travels within the province were planted as original stocks. The station began the distribution of cuttings during the last half of 1937 and from the 8 hectares planted, there were supplied 120,392 cuttings in 1937 and 603,361 in 1938, up to the time the station was transferred to the new management. The money value of this distribution (at ₱5 per thousand cuttings) and the hectarage covered when planted with these cuttings, stand as an accomplishment of the station within so short a span of time, to say nothing of the services given to Negros farmers in the way of information and cultural instructions on the crop. Today Negros has about 580 hectares planted to derris, in the promotion of which the station played a major rôle.

(*e*) *Beans.*—With respect to minor horticultural crops the station conducted trials and studies on different legumes such as different varieties of soy bean, cowpeas, kibal, sitao, *panubigan* bean, bountiful bean, and other beans. The objects were to determine the possibilities of the crops for commercial production in connection with crop diversification work; to conduct studies on the best time and manner of culture; and to determine their secondary uses as soil renovators, and as animal feed.

The possibilities of beans for Negros are bright as the soil and climate are favorable to the growing of the crops. The cultural trials conducted by the station along this line were instrumental in popularizing the commercial planting of the *panubigan* bean, the variety popularly called "habichuelas ver-

des" having red and white colored dry beans. Special mention is made of the different varieties of soy beans, from the old Ami variety to the recently introduced and improved kinds as the Macoupin, Otamao, Danfield, Mis Dixie 33, and other varieties. The results of the trials proved beyond reasonable doubt the importance of the crops, both in the production of beans and forage and cover crops. Soy bean may in the near future form the basis of new industries on oil, sauce, and paints in Negros.

(*f*) *Forage and cover crops.*—In connection with the previous animal husbandry project of the station, different forage grasses such as the Uba cane, Napier, Guatemala, Sudan, Para and Guinea grasses were also introduced, tried and cultured.

Negros was and still is dependent to a great extent on work animals for its farm operations, and realizing the value of grasses for feed, the station distributed to the farmers planting materials of these different grasses. The Para and the Guinea grasses are now the standard feeds for big and small animals in the province. The extent to which these grasses are being grown can better be appreciated by mentioning the fact that Negros has a number of work animals in all haciendas. Incidentally, the rich families such as the Ledesmas, Jalandonis, Aranetas, Montelibanos, Montillas, Ascalons, Ferias, Presbiteros, Lopezes, and others, are raising cattle, horses, poultry and swine. The Guinea and Para grasses form the bulk of green feeds of these animals as these forage grasses are now grown throughout the province. The raising of these forage grasses had its origin in the initial work of the station in conjunction with the work on livestock.

With respect to cover crops the station popularized the use of such cover crops as Centrosema, Calopogonium, Tephrosia, and ipil-ipil. Farmers availed themselves of the use of these cover crops either as soil renovators, as weed exterminators or as shade plants. The popularity in the use of these crops can be gauged by their presence in a number of big orchards throughout the province.

(*g*) *Vegetable project.*—The station also devoted part of its area to the planting of a variety of vegetable plants such as the eggplant, papaya, pepper, patola, seguidillas, sincamas, upo, cucumber, squash, condol, talinum, and malungay. The main object was the production of planting materials (seeds and cut-

tings) for distribution at the Central Office, the cultures serving as demonstration plots. Seeds were kept at the station to supply local demand and the district's needs for rural improvement work. The planting of vegetables around the homes of laborers in hacienda communities became widespread as a result of the station's efforts in this regard.

(*h*) *Tobacco project.*—Late in the 1934–1935 crop year, when the sugar limitation law was enforced, the station introduced the growing of the wrapper and the cigarette tobacco varieties for adaptability trials in the search for other crop substitutes. The project was carried yearly until the station was leased and the results obtained during four years showed promise for the wrapper varieties. Widespread interest was aroused in the growing of the wrapper tobacco but the uncertainty of the market for the crop just now is a deterrent among the able planters. During these years the station became one of the big sources of seeds of wrapper and cigarette tobacco for distribution by the Central Office.

With the marked similarity of the rainfall and climatic conditions of Negros to those of Java and the fact that actually tobacco is one of the principal crops of the province, it is only a matter of time now with this program of agricultural adjustment when the growing of tobacco of a better quality and on a bigger scale will be seriously undertaken. Forerunner of this is the erection in 1937 of a modern tobacco curing flue by Mr. J. Cooper at Hacienda Boyog, Escalante, one of the towns of the province noted for its tobacco crop.

2. *Nursery and orchard projects.*—The raising of fruit tree seedlings of commercial value became part of the routine work of the station as soon as seeds and propagating materials were obtained from its bearing trees planted in 1915. The work, however, was given more impetus when the operation of the station was bolstered up with the Seed Farm Fund of 1928–1929. Propagation on a commercial scale of different seedlings, as well as budded, grafted and marcotted plants was then undertaken for purposes of distribution. Then too, with the sugar limitation which implied the necessity of crop diversification, the nursery work was stressed. In the last few years since the limitation took effect, the demand for fruit tree seedlings was

especially great as will be seen in the following records of distribution:

	Number of seedlings	
1935	23,344	budded, grafted and marcotted.
1936	21,993	Do.
1937	16,621	Do.
1938 (January to June 30)	15,867	Do.
Total	77,825	

To the station goes the credit for establishing a number of big orchards in the province. The general interest among the people in the planting of trees was doubtless brought about by the fact that the station consistently maintained within its premises model orchards of different kinds of fruit trees including coffee.

Negros, for instance, is considered at present to be one of the leading avocado producing provinces. It produces besides other fruit trees like the caimito, tiessa, serali, oranges, and pineapple, on a semi-commercial scale in various haciendas. Among the biggest fruit orchards in the province are those owned by Don Nicolas Lizares, Mayor Alfredo Montelibano and Don Generoso Villanueva of Bacolod; Assemblyman Pedro Hernaez, and Albino Jison of Silay; North Negros Central and Dr. Doroteo Kabayao of Manapla; Victorias Central, and the Valderrama family of Victorias; Don Gil Lopez and the Avanceña family of Cadiz; Domingo Siocon and the Mapa family of Talisay; the Mambucal Spring, summer resort of the province in Murcia; Don Aguedo Gonzaga and Don Raymundo Yusay of Bago; Don Espiridion Presbitero and Doña Dolores Infante of Valladolid; Don Toribio Echarri and Don Vicente Jimenez Yanzon of La Carlota; Don Enrique Esteban and Jesus Esteban of La Castellana; Don Antonio Milan and the Montilla family of Isabela and Ilog; the Binalbagan Sugar Estate and the Marquez Estate in Binalbagan; and haciendas in other towns of the province.

The educational aspect of the work, whereby the people ultimately learned the value of fruits in their daily diet should not be lost sight of. In all these years, the station has been known in the entire province for its myriad variety of fruits and the popularity now enjoyed by the avocado, tiessa, serali, caimito and oranges in the local markets remains as a permanent legacy bequeathed to the Negros people by the station.

At the time of its transfer the station had the following fruit trees producing the necessary seeds and budsticks, for propagation purposes to supply local needs as well as those of the Central Office, other stations of the Bureau, provincial nurseries, and private parties:

Name	Number of trees	Years planted	Name	Number of trees	Years planted
African oil palm	50	6	Kapok	114	18
Anona hybrid	2	18	Kayam	1	15
Ates	13	8	Ketembilla	2	22
Avocado	378	3-22	Lanzones	6	11
Alpay	7	9-20	Lemon	2	6
Crab-apple	1	15	Lime (2 varieties)	7	6
Biriba	9	9-18	Lemasa	72	6-22
Banati	1	22	Lauriva	1	22
Bael	2	22	Lamuta	1	22
Bananas	256	-----	Malungay	15	4
Beriba	3	6-9	Mango	18	4-22
Binucao	4	9-18	Mabolo	9	4-22
Chico	13	8	Mandarin (12 varieties)	175	2-22
Sweet camias	2	22	Marang	1	22
Cefalus	1	22	Narra tree	5	7-10
Caimito	41	9-18	Papaya	36	3- 6
Calamondin	109	6-22	Pitanga	2	18
Camansi	4	22	Pine tree	2	3
Carambola	5	22	Perunkila	1	6
Chico mamey	3	18	Pummelo (4 varieties)	22	3-20
Coffee	3,837	22	Rimas	1	2
Cacao	13	10	Rambutan	9	2- 8
Cashew	2	8	Sweet orange (16 var.)	140	4- 6
Date palm	1	22	Sour orange	2	6
Genipa	2	18	Santol	15	22-38
Guanabano	8	8	Strychnus spinosa	3	18
Gomihan	2	22	Serali	8	20-22
Guava	5	18	Tizon	19	6
Grapefruit (2 varieties)	6	6	Tamarind	2	22
Huani	2	9-20	Tersana	2	6
Hevi	5	9-18	Tiessa	9	3-18
Iba	2	22	Tangelo	2	6
Icaco	1	18	Wampi	2	9
Ipil (timber)	5	7-10	Yambo	7	6-22
Kanari	2	16-22	Zapote	1	20

3. *Agricultural extension work.*—The activities of the station were not limited to projects within the confines of the farm. The results of its work were also extended to the farming public. The experiments conducted within, and the extension work without, complimented one another in bringing about the rapid promotion of the agricultural development of the province. Beneficial results of agricultural research obtained, high yielding seeds or better planting materials produced, better agricultural practices and methods evolved were all rapidly disseminated for

the benefit of the farmers. Agricultural extension practices such as actual field demonstrations, informative instructions, co-operative plantings, crop drives, farmers' days, community assemblies, participation in local and provincial fairs, etc., were all availed of to the advantage of the people. It is through a strict adherence to the policy of public service that the station gained the confidence of the farmers of Negros. Its contribution to the progress of agriculture in Negros and other parts of the Islands can be attributed to this confidence in and reliance on its leadership.

B. Animal Industries

One of the early projects of the station was that on animal husbandry which was begun in 1910 with the introduction of a few head of Indian cattle. Since then foreign breeds have been introduced. The object of the work was to promote the animal industry in the district through the introduction of better foreign breeds and the improvement of native breeds through upgrading. In this work, the station contributed material benefits to the Negros people in more ways than one, chief among which are the improvement of their native stock of domestic animals with the introduction of the Arabian and Thoroughbred blood in horses; the Indian cattle blood in cattle; that of the Berkshires, Poland Chinas, and Duroc Jerseys in swine; that of the White Leghorns, the Cantonese and the Rhode Island Reds, in poultry. The blood of these imported improved breeds is now very evident in the common stock breeds in the various haciendas in Negros. Another major accomplishment in connection with the animal industry project was the work in the control of animal diseases like rinderpest, surra, the foot-and-mouth disease, and other diseases which constantly menaced the work animals and herds of the province in the early years of the station.

The animal husbandry project of the station was closed with the creation of the Bureau of Animal Industry in 1929 by virtue of Act No. 3639 splitting the then Bureau of Agriculture into the two sister Bureaus, the Bureau of Plant Industry and the Bureau of Animal Industry. The latter Office put up its own station within the land apportioned to it. The same line of activities in animal improvement as started by the station is still being pursued by the Animal Industry Stock Farm for the benefit of the Negros people.

C. Expenses and Income

As stated elsewhere in this paper, the station was the most profitable experiment station of the Bureau. Being an experiment station, it was not expected to give monetary returns, and yet it justified its later operations by returning to the Government more than the annual investments made in maintaining it. A close study of the financial status of the station for the last five (5) years beginning 1934 will bear us out in this:

Year	Expenses	Gross income	Net income
1934	₱12,969.02	₱27,365.34	₱14,396.32
1935	9,126.02	20,965.59	11,839.57
1936	23,811.69	30,219.59	6,437.90
1937	22,423.58	28,438.81	6,015.23
1938	13,763.84	28,331.22	14,667.38
Total	82,094.15	135,350.55	53,356.40

PRESENT WORTH AND INVENTORY OF STANDING CROPS, PROPERTIES AND PRESENT IMPROVEMENTS

In presenting an honest appraisal of the work of the station at the time of its transfer, August 15, 1938, an inventory of the standing improvements alone is not all that should enter into consideration. There is the good will that the station acquired based upon the disinterested public service in agriculture that it offered since the beginning. This unselfish public service was largely what earned for the station the good name and the credit that it enjoyed in its relations with the public. Pecuniary consideration is no measure of justification for the intrinsic merit of what the station has done or stood for.

The following is the inventory of the standing permanent plantings and annual crops at the time of transfer, as culled from a report of Mr. F. G. Galang, Chief of the Horticulture Section of this Bureau:

Total estimated value of standing annual and permanent plantings of economic plants	₱48,692.75
Total cash income from January to August 15, 1938 (date of transfer)	28,331.22
Total	₱77,023.97

The inventory values of the land, buildings, equipments, tools, and other properties of the station as appraised by the Property Officer of the Bureau at the time of transfer amounted to ₱522,001.37.

The total money value, therefore, that was represented in the leasing of the station amounted to ₱599,025.34, of which

the amount of ₱496,312.40 represented the value of the land and its sugar quota. The sum of ₱102,712.94 represented the station's income from January to August and the value of standing improvements and working equipments essential in the operation of the farm.

SUMMARY

1. With the signing of the contract of lease by and between the Agricultural Service, Inc., and the Philippine Commonwealth, on July 23, 1938, the Granja Sugar Cane Experiment Station terminated its activities under Government operation and supervision.
2. The rental is ₱12,000 per annum.
3. The Granja Sugar Cane Experiment Station was the best developed and the most profitable experiment station of the Bureau.
4. In the last five years of its operation, 1934–38, under the management of the writer, the station showed the following expenses and income:

Expenses	₱82,094.15
Gross income	135,350.55
Net income	53,356.40

5. At the time of transfer it was 48 years old—10 years under the Spanish régime, 35 years under American rule, and 3 years under the Philippine Commonwealth. It had seen antiquated muscovado mills transformed into modern sugar centrals. Its activities had grown from the old hit-and-miss farming to that of modern and scientific methods.
6. The entire area of 496.3124 hectares is all under cultivation and has 116 families living within its confines with a total population of 574 persons who are dependent for their livelihood on the station.
7. The station has a sugar quota of 14,134 piculs.
8. It helped the sugar industry by:
   (*a*) Introducing and conducting trials and studies on both foreign and local sugar-cane varieties.
   (*b*) Distributing superior sugar-cane varieties to planters.
   (*c*) Conducting researches and experiments on better cultural methods in sugar cane growing and improved methods of sugar manufacture, and studies on sugar-cane pests and diseases and their control.
   (*d*) Producing the famous L. C. 25/191 (Alunan sugar cane), now one of the standard sugar-cane varieties of Negros, and other promising seedling canes.

9. With the advent of sugar limitation it pushed forward the program of crop diversification as a remedial measure in agricultural adjustment. This crop diversification program was the outcome of trials and experiments on crop substitutes resulting in the production of selected and improved varieties of seeds and plants for crop promotion drives. The province since the limitation is gradually being weaned away from one crop specialization to crop diversification. Industrialization to harness excess power in centrals may easily follow the production of cheap raw materials.

10. Its work on animal industry materially improved the breed of domestic animals and made the province safer from the ravages of serious animal diseases than in the past.

11. With its disinterested service in the promotion of agriculture, the station gained public confidence. It was this confidence that bestowed upon the station the enviable agricultural leadership it enjoyed among the people during the years of its existence.

12. Its name "La Granja" is a household word among the people of the province as well as among farmers in nearby Visayan provinces and taken as the seat of modern agricultural practices and advancement; noted for its selected and improved planting materials, its fruits and animals.

All things considered, the Granja Sugar Cane Experiment Station led 36 years of life and disinterested public service to the full.

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ILLUSTRATIONS

(All views taken at the Granja Sugar Cane Experiment Station, La Granja, La Carlota, Occidental Negros)

PLATE 1

Characteristic stalks and nodes of different sugar cane varieties.

PLATE 2

Cutting a matured hybridized arrow, the seeds of which are for germination.

PLATE 3

Seedling canes in the nursery during the years of hybridization work.

PLATE 4

FIG. 1. Java 247, male parent of Alunan cane.
2. Badila, female parent of Alunan cane.
3. Alunan cane (L. C. 25/191), one hill.

PLATE 5

FIG. 1. L. C. 25/190 (Labrador cane).
Parentage, Java 247 and Badila.
2. L. C. 30/100 (La Granja cane).
Parentage, P. O. J. 2878 and P. B. 119.

PLATE 6

A single plant of the La Granja cane, 6 months old.

PLATE 7

A field of Alunan cane.

PLATE 8

FIG. 1. A field of rice, variety Apostol.
2. A field of Calamba Yellow corn.

PLATE 9

Dumali (upland rice), a month old, interplanted with Calamba Yellow corn.

PLATE 10

Fields of different varieties of cassava.

PLATE 11

A field of cotton, Cleveland big boll variety.

PLATE 12

FIG. 1. African oil palm.
2. Bunches of fruits, nuts and seedlings of the African oil palm.

PLATE 13

A field of derris (Derris elliptica).

PLATE 14

FIG. 1. Soy bean (Macoupin) in the foreground; Bountiful bean a little behind.
2. Singapore sitao grown for the production of seeds.

PLATE 15

Guinea grass (forage grass).

PLATE 16

FIG. 1. Tobacco seedbed.
2. Tobacco plants with fully mature leaves, ready to be harvested.
3. Tobacco field, partly harvested.

PLATE 17

FIG. 1. Okra in the foreground, flanked by Hawaiian pineapple and Mexican June corn.
2. A field of mulberry trees with eggplants planted in between the rows.
3. A field of wheat.

PLATE 18

FIG. 1. The source of the springs for gourami, frogs, ducks, "dalag" and "martinico" beds.
2. Frog culture.

PLATE 19

FIG. 1. An avocado tree.
2. Caimito fruits.
3. Caimito tree with fruits.

PLATE 20

FIG. 1. Budded Washington navel orange, 5 years old.
2. Tiessa fruit, long variety.

PLATE 21

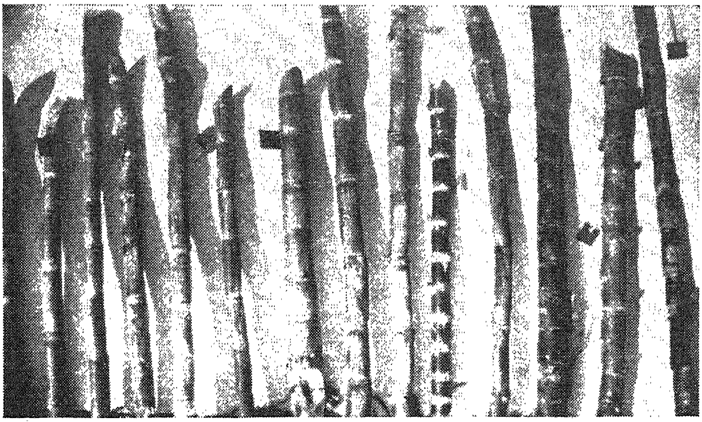
FIG. 1. Budded pineapple orange, 5 years old.
2. Marcotted serali.

PLATE 22

Early stock of Indian cows and bullocks.

PLATE 23

Park and gardens of the Station.



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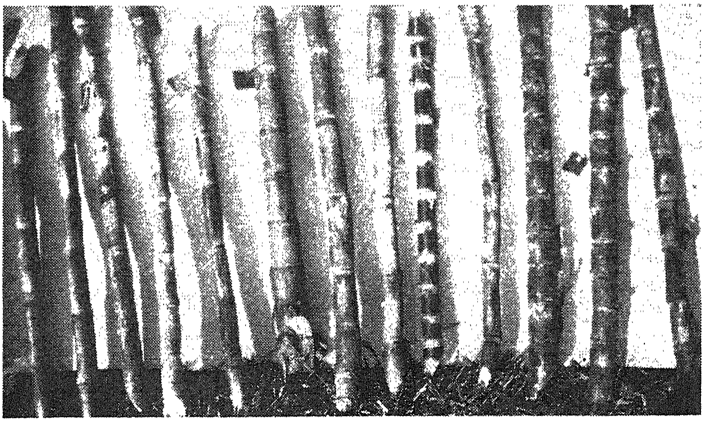

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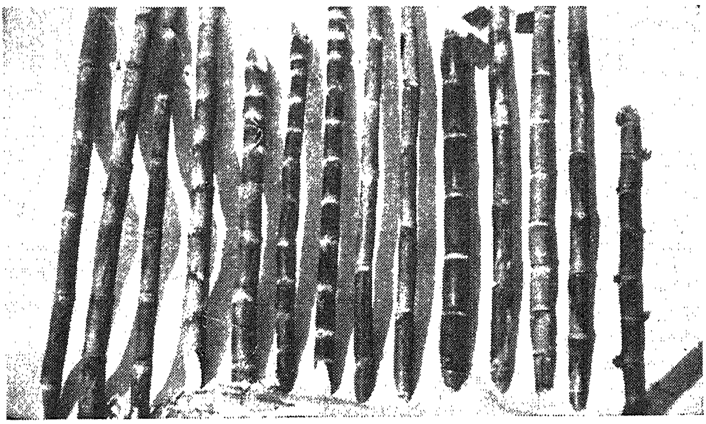

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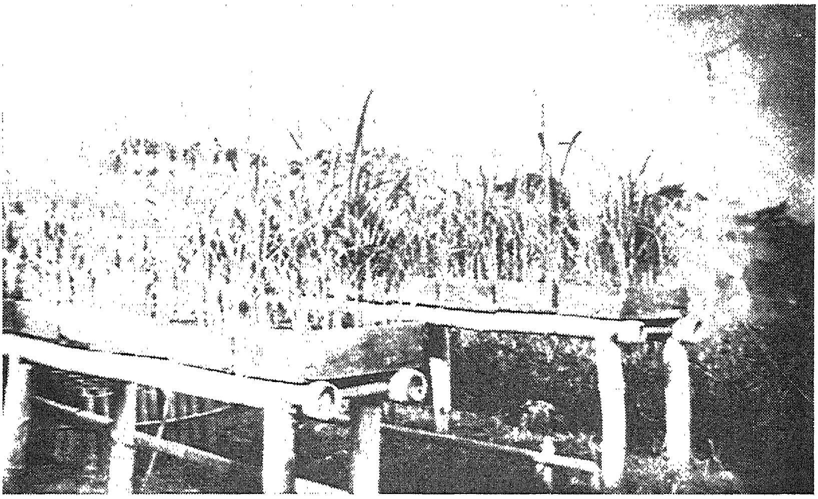
PLATE 1.

PLATE 2.



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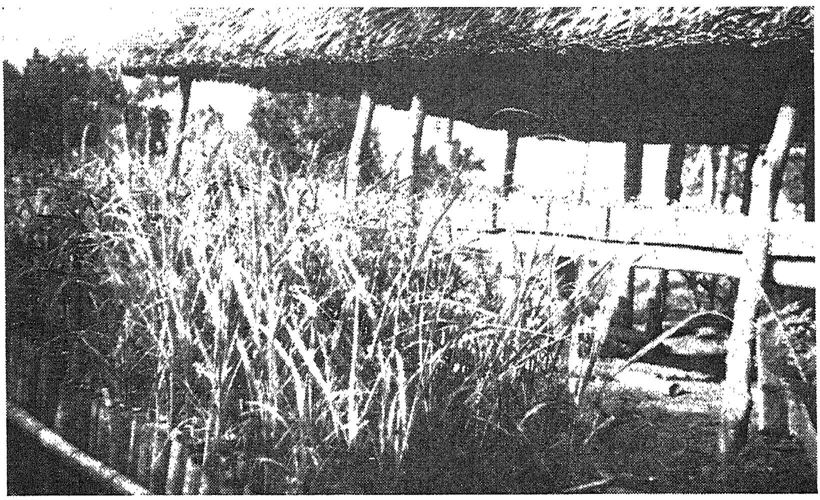

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PLATE 3.

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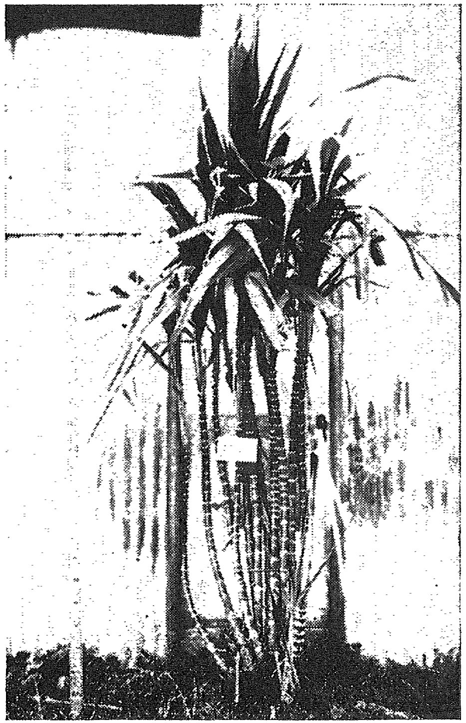

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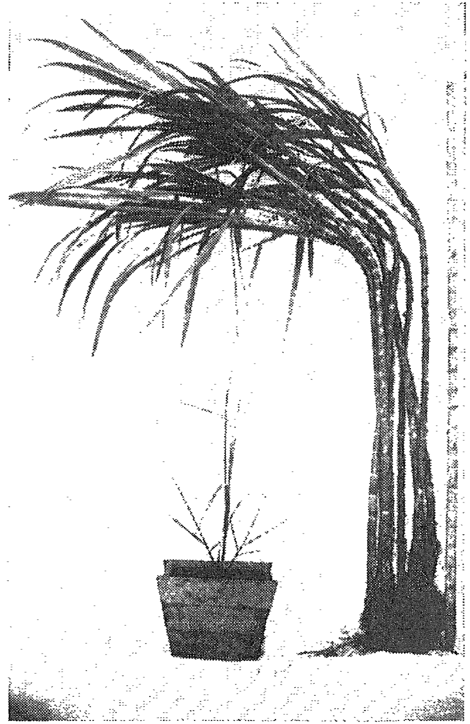

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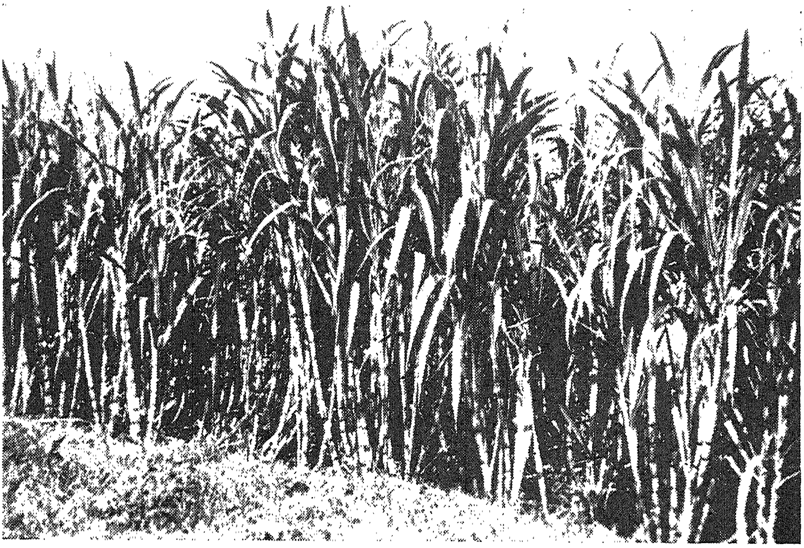

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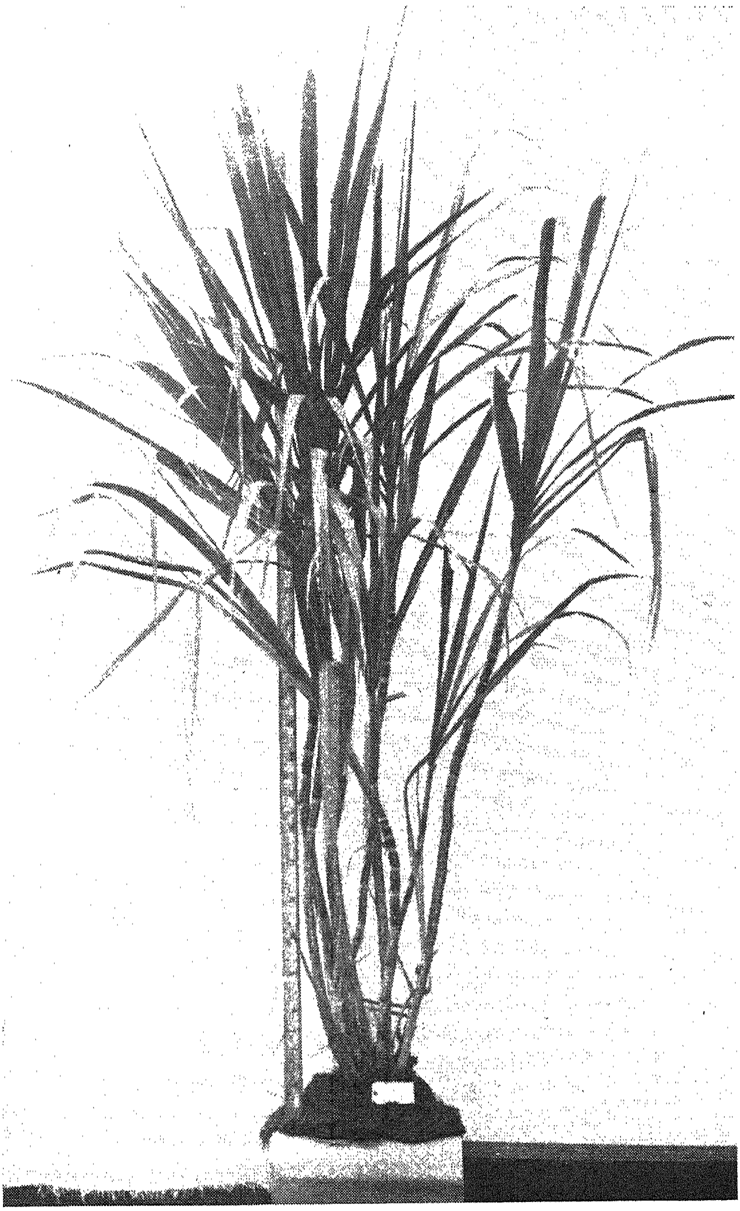

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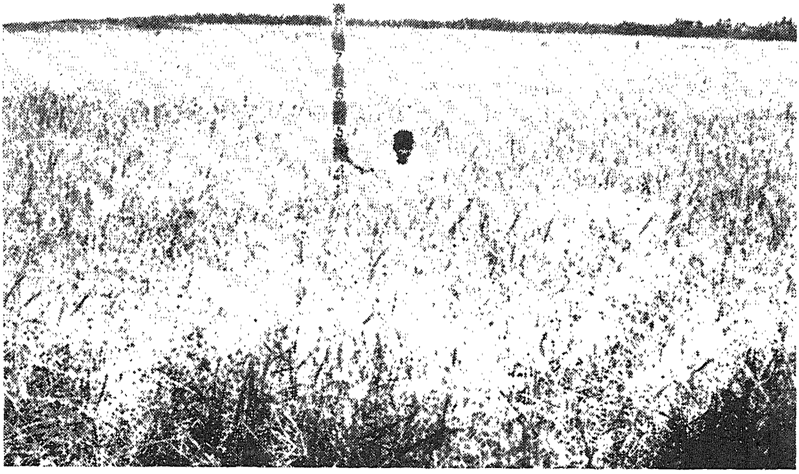

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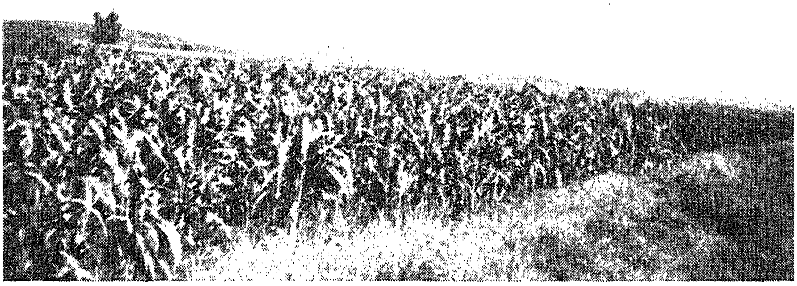

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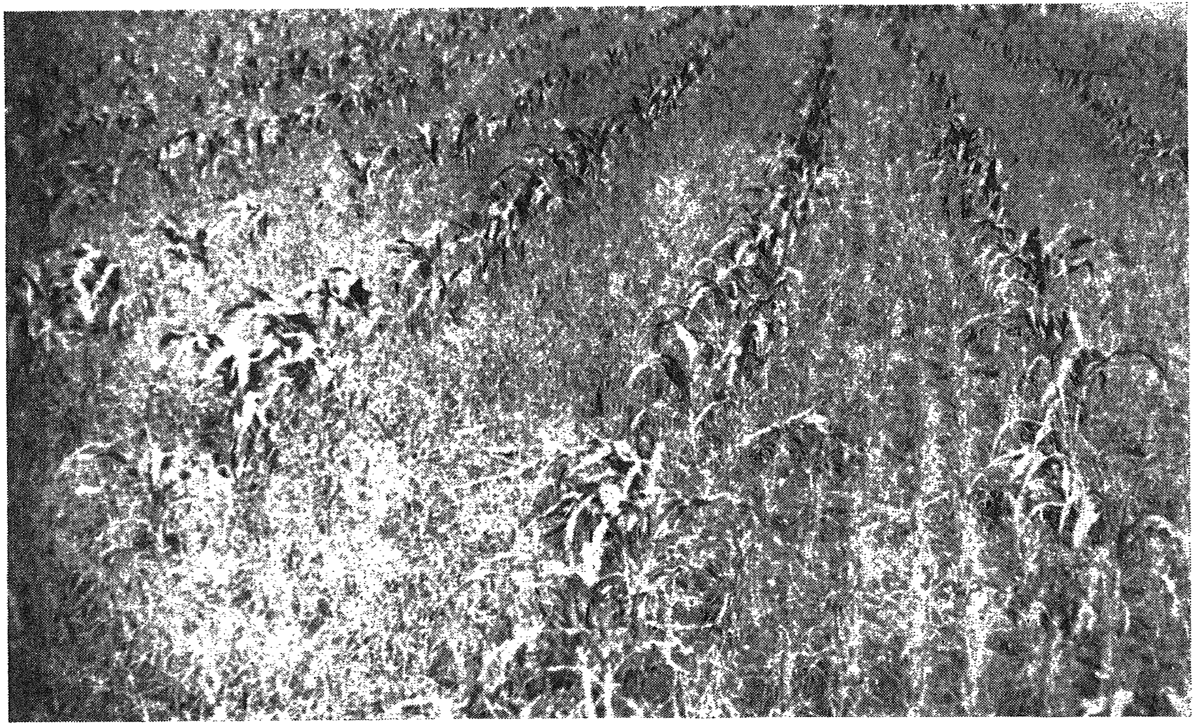

PLATE 9.

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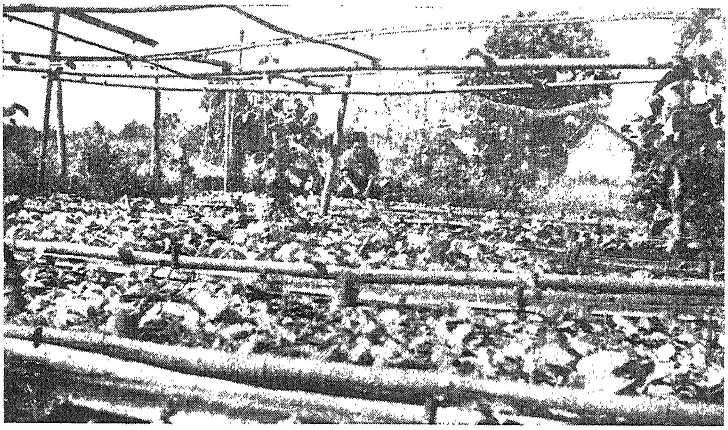

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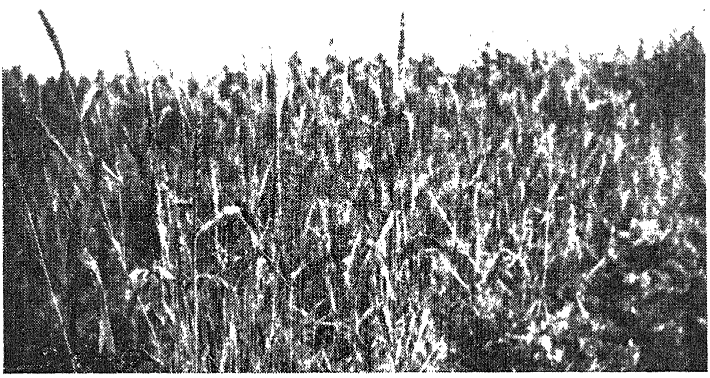

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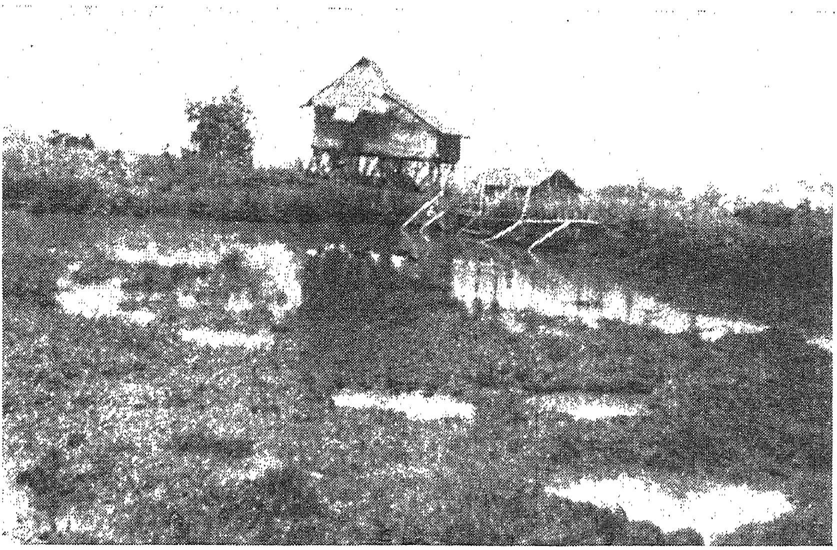

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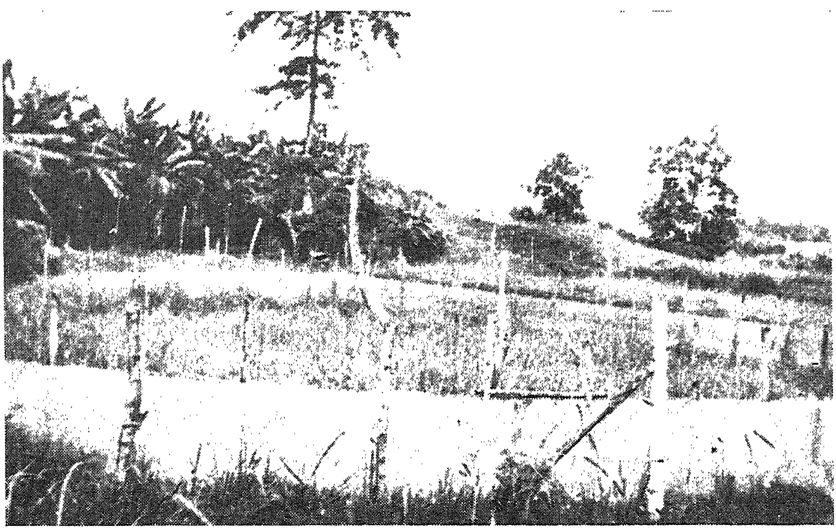

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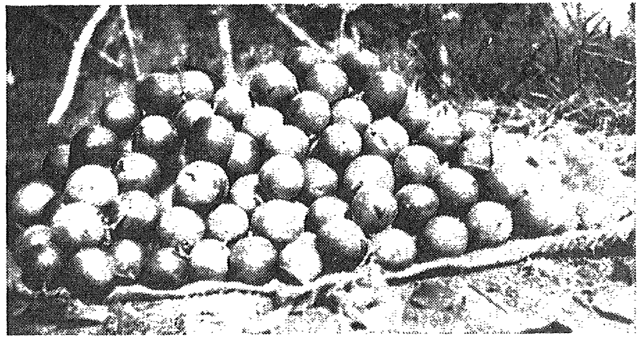

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PLATE 19.

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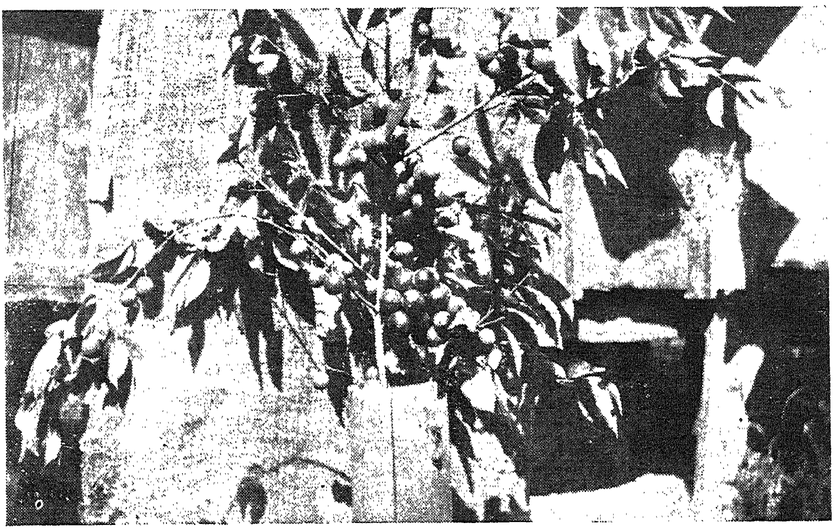

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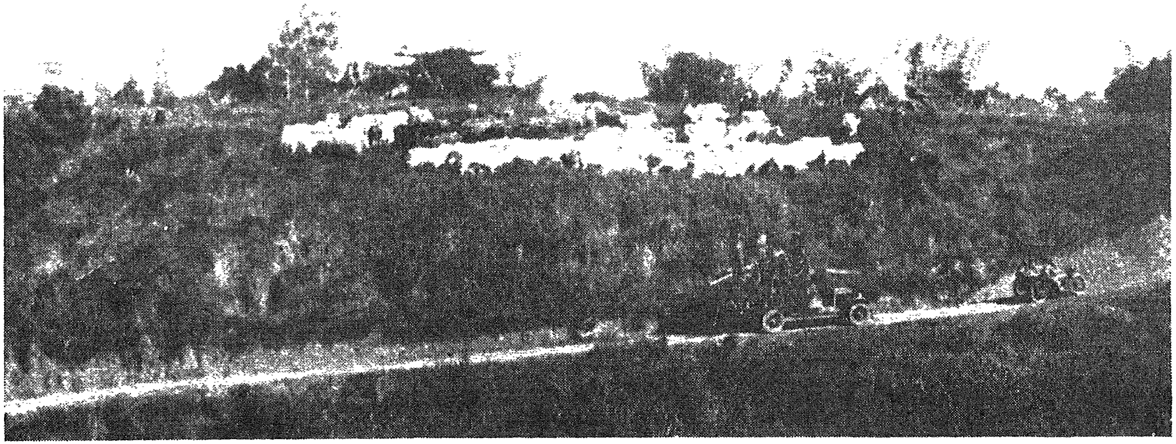

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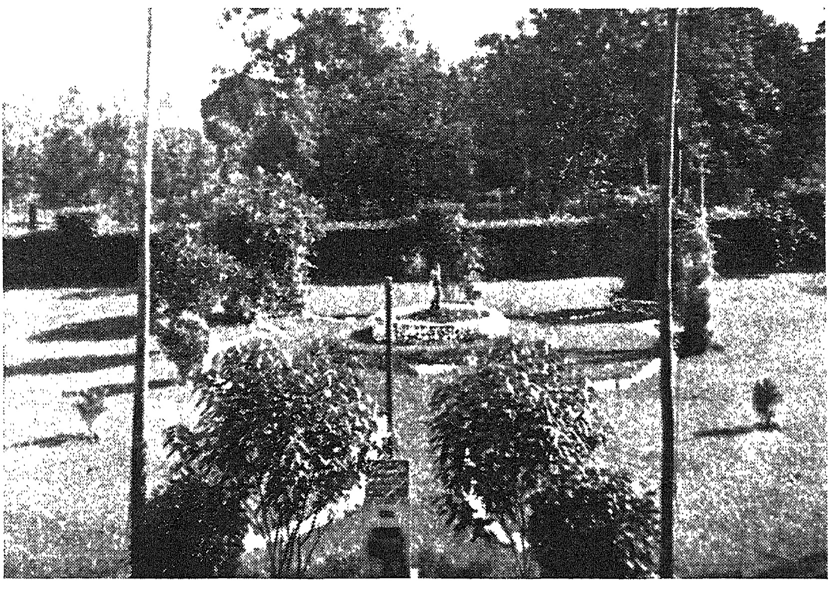

PLATE 23.

THE CACAO INDUSTRY IN THE PHILIPPINES *

By Epitacio A. Lanuza

Of the Horticulture Section, Bureau of Plant Industry

INTRODUCTION

Concededly one of the most profitable crops in the Philippines (given favorable conditions and free from the menace of serious pests and diseases) is the cacao, *Theobroma cacao* L., belonging to the family Sterculiaceae. A native of tropical America, cacao was first introduced into the Philippines by the Spaniards at an early date. From Mexico and Central America, the cultivation spread to the West Indies and to South America finally radiating as far as West Africa, Ceylon, Java and in many parts of the world including the Philippines. Merrill describes the plant as follows:

> A tree 3 to 5 meters high. Leaves 15 to 40 cm. long, acuminate, base rounded oblong-obovate to oblong, base shortly 3-nerved. Flowers solitary or fascicled on the trunk and branches, yellowish or nearly white, pedicelled, about 1 cm. in diameter, the erect lobes of the staminal column purplish. Fruit oblong, 10 to 15 cm. long, prominently wrinkled, yellow or purplish. Seeds numerous. Flower all the year round.

Barrett, in a stirring lavender account about cacao, tells us that at the time of the Spanish invasion of Mexico in the early part of the 16th century, "chocolatl" (the Aztec name for cacao) was used both as a popular beverage material as well as a product which literally served the purpose of "coin of the realm" or as a medium of exchange, its seeds being used by the natives in paying taxes and tributes. In the middle of the 17th century the chocolate, a term first used by the English, definitely entered in the European diet.

Cacao is still a crop of great commercial possibilities in the Philippines both for local consumption and for export. The best available areas in the cacao-producing countries have been fully developed in the past decade, leaving only marginal lands to meet the needs of increasing consumption. The older producing countries are finding it more and more difficult to maintain their normal production. This, abetted by the fact that new uses of cacao are being discovered from time to time, may in due time usher in a condition when the consumption of cacao

* Prepared for the Golden Gate International Exposition, San Francisco, Cal., U. S. A.

will outstrip production to such an extent as to cause a serious shortage in the supply of raw cacao for manufacturing purposes. While the commercial possibilities of this crop have long been a matter of common knowledge among the rank and file of Filipino farmers, still the progress of the Philippine cacao industry has been relatively slow and niggardly and no attempt whatsoever has been made to establish big cacao estates in the Philippines. At present cacao is cultivated in the Islands mostly around the houses.

STATISTICAL DATA

Up to about 1912, Ecuador held undisputed control of the world's production of cacao until affluent British interests in the Gold Coast brushed her aside to become the world's top cacao producer.

At present, there are 28 important cacao-producing countries in the world with a combined annual shipment of 622,000 tons. The British colonies alone produce about 62 per cent of the above figure and the other countries 38 per cent.

There are 41 countries importing cacao beans—principally the United States, Germany, Netherlands, Great Britain and Ireland with a combined annual importation of 584,400 tons.

The bulk of Philippine annual importation of cacao amounting to about 2,000 tons, valued at more than a million pesos come mostly from the British and the Dutch East Indies with the exception of manufactured cacao valued at over five hundred thousand pesos which we generally import from the United States.

In 1936 a total of 2,211,190 trees were planted in the Philippines occupying an aggregate area of 1,548 hectares. Of these trees, 1,190,850 were in bearing during the same year and yielded 798,080 kilos of cacao seed valued at ₱601,810. The Philippine average yearly consumption amounts to over three thousand tons valued at nearly two and a half million pesos.

During the same period the ten leading cacao-producing provinces named in the order of their consequence are Oriental Negros, Cebu, Bohol, Cavite, Leyte, Iloilo, La Union, Tayabas, Occidental Negros, and Pangasinan. More than 55 per cent of the total crop in 1936 was raised in these provinces.

In no instance has Philippine exports of cacao reached appreciable quantities to warrant its being listed alongside the country's minor exports. Our cacao exports, including re-exports (cacao imported into the Islands and then exported back

to China, British Indies, French East Indies, Hongkong, and Japan) in 1936 and in 1937 aggregated a trifle 10,179 kilos valued at ₱4,655 and 4,630 kilos valued at ₱1,932, respectively.

CULTIVATION

Varieties.—The principal cacao varieties known to world's commerce as mentioned by Barrett are: (1) Criollo of which there are three or four recognized types like the Venezuela, Nicaragua, and Trinidad; (2) Forastero; (3) Calbabacillo; (4) Pentagona or Alligator; (5) Bicolor or Tiger; and (6) Shaerocarpa. The same author mentioned certain strains of the Forastero and the Criollo as the principal Philippine cacao varieties. No systematic study has been made thus far of the existing cacao varieties in the Philippines. However, two easily recognized types are found cultivated, namely, the red or purple and the white or yellow. Of these two the most widely grown is the purple. An intermediate type known locally as "Linomot," is grown in the Bicol region.

Soil and climatic requirements.—Cacao being strictly a tropical plant, the existing soil conditions, seasons, and distribution of rainfall in most parts of the Philippines make the country ideal for the commercial planting of the same. Then, too, the Islands fall within the geographical zone admittedly suitable for the successful growing of cacao—to be precise between latitudes 4° 30′ and 21° 30′ north and longitudes 116° and 127° east.

Cacao thrives best in a well drained fertile loamy soil with a substantial amount of humus and with a mean temperature of 26° C. to 28° C. and a precipitation of 1,600 to 2,200 mm., which is fairly well distributed throughout the year. A pronounced dry season is not conducive to the growing of cacao on a commercial scale.

Not only should the soil and rainfall be favorable but also the land planted be well beyond the paths of strong winds. Adequate provision for windbreaks should be made therefore in lands which are exposed to strong winds. Soils with an elevation not more than 800 meters above sea level are most suitable for cacao culture.

Extensive areas for the growing of cacao are still available today in many parts of Mindanao, the Bicol region, Mindoro, Palawan, Isabela and in the Visayan Islands. In these sections alone there are vast tracts of land whose soil and climate are made to order for the delicate requirements of cacao trees.

Propagation.—In the Philippines, vegetative propagation especially budding of cacao has not been extensively practiced. The only system of propagation in vogue is by seeds. The farmers select the best mature pods from productive trees that they can get hold of for seed purposes. Because seeds easily lose their vitality, they are, therefore, planted immediately after the pulp and membranes have been washed off with clean fresh water.

The following methods are in vogue in the sowing of the seeds: (1) Direct in bamboo tubes or pots with good garden soil, planting a seed in each tube or pot at a depth of 2 to 3 cm. below the surface. A conveniently-sized hole for drainage is made at the joint or node of the bamboo tube. At the bottom pieces of gravel or stones are placed before putting in the soil; (2) in receptacles devised for the purpose, such as bark of wood, or banana leaves in case these materials are easily and economically obtained. Sowing in such receptacles proceeds in the same manner as that in bamboo tubes; (3) in seed boxes or seed beds. and for the former using a mixture of compost and garden soil as medium, or of fertile soil mixed with fine river sand. In all cases it is essential that partial shading be observed.

In the last method the seedlings are later on potted in bamboo tubes when the first pair of true leaves appear. In potting the seedlings the main roots are nipped off to induce branching.

Planting.—When the seedlings reach a height of about 40 cm. or more they are transplanted in permanent fields. Transplanting is done at the beginning of the rainy season. The seedlings are set in holes of at least 40 or more cubic centimeters and distanced at 4 to 5 meters. The seedlings are planted at the same depth as in the pot. The holes are then filled with rich surface soil. The newly planted seedlings are watered after setting whenever it is necessary. It will cost from ₱150 to ₱250 to plant a hectare of cacao depending upon the kind of land, and between ₱25 to ₱50 a hectare to maintain the plantation.

Cultivation.—It is essential that cacao be partially shaded. For this purpose leguminous trees such as ipil-ipil, *Leucaena glauca* (Linn.) Benth., and madre-cacao, *Gliricidia sepium* (Jacq.) Steud. are used. To a very limited extent other shade trees are used, such as avocado, *Persea americana* Mill., nangca, *Artocarpus integrifolia* L. f. and other fruit trees. Without permanent shade at the start, temporary shading is necessary during a couple of years. For this purpose *Tephrosia candida*

(Roxb.) DC., cadios, *Cajanus cajan* [Linn.] Merr. or banana, *Musa sapientum* may be used.

The temporary shades are not allowed to interfere with the free growth of the cacao trees. Every now and then the shade trees are pruned and thinned off as the permanent trees grow bigger.

Shallow cultivation or at least ring weeding is performed to enhance the growth of the plants. The former operation—shallow plowing—is practiced within the first two years to promote deeper rooting system. Ring weeding is done as often as three times a year or only in case the same is very necessary depending upon the growth of weeds.

Cacao, like many other fruit trees, needs judicious pruning not only to cut the dead, decaying, or diseased branches but also to get good formation of the crown and branches, using sharp pruning tools for the purpose. Cuts or wounds are painted with white lead or coal tar.

Pests and diseases.—Pests and diseases are the only limiting factors to the successful growing of cacao in the Philippines. These hazards, however, are now being overcome by improving the methods of culture and seed selection; by proper methods of control, by the proper use of shade, and by the use of other devices, all of which are now commonly practiced by the farmers.

The pod borer, *Acrocercops cramerella*, and the stem borer, *Zeuzera coffeae*, are the most serious pests attacking cacao trees in the Islands. These pests are controlled either by spraying, by collecting and destroying the beetles, by pruning and burning the dead and affected branches, or by dropping into the holes, in the case of the latter, carbon bisulfite or paradichlorobenzene. The holes are then plugged with wax, mud, or paraffin.

Other pests that are fairly serious at times are the mealy bugs, *Pseudococcus lilacinus* and *P. citri*. Both insects are controlled by soap solution (150 grams per kerosene can of solution), or by kerosene emulsion sprays.

Of the diseases, the most serious are the so-called black rot and canker, *Phytophthora faberi*. The former attacks the pods and the latter the stems. Spraying with Bordeaux mixture (4–4–50) or lime sulphur and observing strict sanitary measures in the plantation are the most effective control measures against these diseases.

Harvesting.—In general cacao trees in the Philippines begin to fruit in 4 to 5 years, or in some cases earlier. The flowers

develop into mature fruits in six months time. The fruits should be picked as soon as they are fairly matured or when they begin to show signs of ripening. If allowed to be over-ripe the seeds are liable to germinate and fermentation might occur. On the other hand, if the fruits are prematurely gathered, the seeds have no chance to ferment. Although a sharp knife or shears should be used in clipping off the pods so as not to injure the attachment, the present practice is to pick the fruits with the hands or with the use of a hook.

It is necessary that seeds be fermented in order to get the desirable taste and color as well as to kill the embryo. This is, however, an operation often overlooked by the average Filipino cacao growers, probably due to the fact that cacao is produced on a small scale at present. After washing the beans with clean fresh water they are dried in the sun. A complete dyring is indicated by a lustrous reddish-brown appearance of the bean surfaces. Beans thus dried break readily and with the inside of the kernels turned brown.

Uses and economic importance.—There are many uses of cacao in manufactures. Cacao is sold in the market as chocolate, ice-cream, powdered cacao, chocolate milk, cakes, cacao-nibs, cacao butter, cacao wine, chocolate soda, and in various forms of confectionery. It is likely that more uses of cacao will eventually be found. However, in the Philippines at present cacao is generally used only in making beverages, candies, or drinks.

In many places cacao has gained at once the fancy of users upon introduction. For instance, of the 250 tons consumed in 1882 more than half was consumed by the British navy. In 1888 English consumption increased to 9,000 tons and by about 1908 it had risen to 23,000 tons or more than one pound a year per capita.

The average increase in the world's consumption of cacao from 1932 to 1936 was from 0.69 to 1.56 per cent.

Statistics show that the United States is a potential market for cacao. Of the 41 countries importing cacao, the United States imports about 234,660 tons a year. Cacao is duty free both in the United States and in Holland, two great cacao-consuming countries. These two countries draw the bulk of their cacao imports from British West Africa, Brazil, Dominican Republic, Jamaica and Netherlands. Both America and Europe can consume a few thousand tons without in any way appreciably affecting the average wholesale price.

Cacao is now considered one of the world's staple crops. It is less susceptible to price fluctuations, and it can be kept for a long period.

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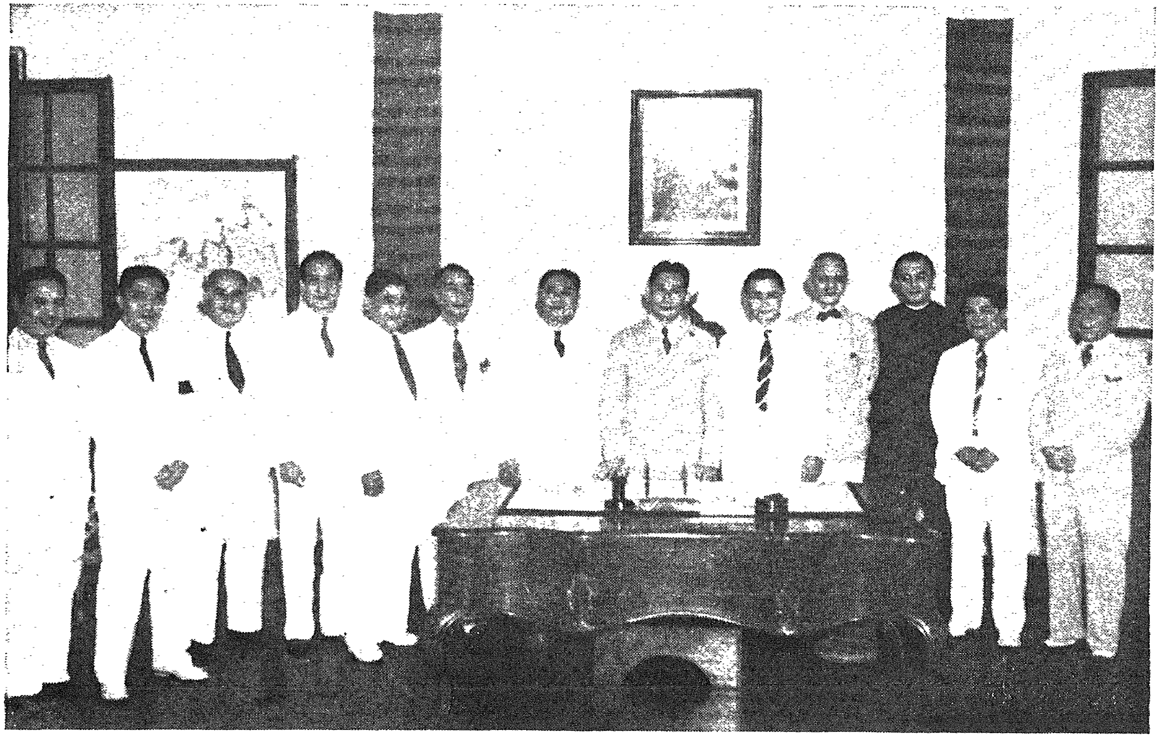


The new Secretary, Hon. Benigno S. Aquino (center) surrounded by the former Secretary, Hon. Eulogio Rodriguez (left), the Under-Secretary, Hon. José S. Camus (right), and the Directors and Chiefs of Bureaus and Offices under the Department of Agriculture and Commerce. (Photograph taken in the Office of the Secretary after his induction into office).

Hon. BENIGNO S. AQUINO

SECRETARY OF AGRICULTURE AND COMMERCE

A country gentleman, had he so chosen to remain and yet a public servant by force of circumstances, having served as a legislator in both Houses of the Philippine Legislature, first as a Representative and later as a Senator and still later as a member of the First National Assembly under the Commonwealth Government, that is the public record of the new Secretary of Agriculture and Commerce, Hon. Benigno S. Aquino who was inducted into office on November 28, 1938. Hon. Aquino brings forth into his exalted position not only an exuberant note of masculine vigour tempered with ministerial dignity which is as genuine as his political star but also the far-seeing eye of the statesman, developed during his many years of very close association with the foremost statesmen of this country, which is so necessary in our program of economic readjustment. The keen world struggle for supremacy in the possession of raw materials, not to mention the traditional itch for colonies of world powers as exemplified by very recent and actual world events, demands a re-orientation in our agricultural and fishing policies. His Excellency, President Quezon, is to be congratulated for having entrusted such a key position to this brilliant ex-legislator who is himself a successful landowner in Central Luzon.

The story of the composite life of Secretary Aquino literally bristles with political plums and plummage. Born in Concepcion, Tarlac, on September 3, 1894, young Aquino's richest heritage was his parents: General Servillano Aquino, wealthy rice planter of Central Luzon on the paternal side, and Guadalupe Quiambao, his mother.

As a boy he attended school in a private college in Tarlac thence moving over to San Juan de Letran College where he was graduated with the degree of Bachelor of Arts in 1908. There-

after he took up law in the University of Santo Tomas finishing the course in 1913 and passing the bar examinations the year after.

After five years of active law practice in his hometown, lawyer Aquino then conceded to be a leading figure in the Tarlac bar, presented his candidacy for a seat in the former House of Representatives, now defunct, in 1919. Beating to a punch predictions of political wiseacres who did not take him seriously then, he was elected to office in one of the biggest election landslides on record in Tarlac, with a majority of 2,000 votes in a district where there were barely 7,000 voters. Buttressed by his impressive record as a parliamentarian in his first term in the House, he was easily returned in the succeeding elections of 1922 and again in 1925. His political stock in the House was considerably bolstered up by his election to the post of majority floor leader in 1922, which position he held successfully for six consecutive years.

The year 1928 saw Secretary Aquino's star shine forth to larger destinies. For in that year, he became Senator-elect in a district which had been traditionally on the side of the oppositionists. He acquired prestige as floor leader of the Senate in 1930 and again as acting president of that body on various occasions during the illness of the President of the Senate.

In the First National Assembly under the Commonwealth Government he was chairman of the Commission on Appointments, the most important committee of that body, besides being a member of the Committees on Agriculture, National Defense, Ways and Means, and Pensions. His ministerial mettle, he proved unequivocably at the deliberations of the Inter-Parliamentary Union in Paris in 1927 to which he was sent as head of the Philippine delegation and again as special envoy of President Quezon to Washington when the discussion of the Independence Law was at its tensest in 1932. His political sagacity was amply demonstrated during the 1938 general elections when as general campaign manager of the Nacionalista Party candidates for Assemblymen he helped pull through each and every one of them to the dismay of all oppositionists. He is the sixth and youngest Secretary of Agriculture and Commerce.

Known to a few of his intimates as the Esquire of Concepcion, Secretary Aquino exemplifies the true gentleman. A man of his word and strong convictions, he dares oppose when to oppose is to be in the right. Even as he takes to his favourite stand

in the rostrum to pounce with driving force on the prophets of gloom and disaster and inject confidence in the national state of mind, the Commonwealth sees fit to forge ahead vastly assured that with the Department of Agriculture and Commerce in the hands of this man, the economic patrimony of the country will not be lost.

His views on Philippine economy and its implications may be gleaned from the following excerpts of a speech he, as Secretary of Agriculture and Commerce, delivered before the Convention of Provincial Governors and City Mayors held in Manila on January 20, 1939:

> . . . The per capita average of our foreign commerce, based on the average of the last five years, amounts only to ₱32.52. Compared with the ₱53 for Japan, ₱75.30 for the United States, ₱285.50 for Great Britain, ₱116.60 for France, ₱108.00 for Germany and ₱127.50 for Cuba, ours is obviously insignificant. These figures clearly denote the relatively slow progress we have been making in the economic development of the country, a fact which is attributable only to the lack of efforts we have put forth in the past for the proper exploitation of our vast and promising resources. . . . An intensive exploitation of our natural resources is not only necessary to raise the standard of living of the greatest possible number of our citizens but also to provide adequate revenues for the support of our Government. . . .
>
> The long wait, the lack of coördination, the absence of foresight and excessive red tape noticeable before a poor homesteader could establish his rights of settlement, are defects which the present administration is most desirous of correcting. . . .
>
> . . . because of circumstances, many crops which now appear profitable may become adversely affected and eventually wiped out because of changes resulting from the readjustment of our political relations with the United States. . . . I do not overlook the need of readjusting our production through a campaign of diversification of crops. . . . Our country abounds in raw materials which, converted into cellulose, can be used in the manufacture of rayon. . . .
>
> . . . . It is unnecessary for me to speak to you of other imports which we can easily produce in our country, such as paper, which costs us ₱6,000,000 a year; vegetables, fruits and nuts, another ₱6,000,000; coffee and cacao, ₱3,000,000; beef and dairy products, ₱10,000,000; other food products like fish, meat, confectionery, wines and liquor, ₱30,000,000. It is rather a sad commentary on a country like ours which, with the fertile fields it has for the production of the best kind of tobacco should have to import annually more than ₱15,000,000 worth of cigars and cigarettes. The explanation for this is the exotic influence on our tastes and habits. A coördinated campaign conducted especially by the provincial and municipal governments to bring home to our communities the need of injecting greater Filipinism into our customs and preferences, a campaign which would enhance the virtues of the race, and a constant preaching of prac-

tical nationalism which would arouse in the *masses* pride in what is our own, will serve greatly to reduce, if not totally eliminate these importations and thereby help place our national economy on a strong and durable basis. . . .

Secretary Aquino is married to the former Miss Aurora Aquino. They maintain a home at Concepcion, Tarlac, and another one in Manila.

CIGAR FILLER LEAF TOBACCO CULTURE IN THE PHILIPPINES

(Farmers' Circular 17)

By DOMINGO B. PAGUIRIGAN
Chief, Tobacco Research Section, Bureau of Plant Industry

and

PRIMITIVO TUGADE
Assistant Agronomist, Bureau of Plant Industry

TWO PLATES

Choice of varieties.—The varieties *Marogui, Viscaya, Simmaba* and *Pampano* are recommended for cigar filler culture. These varieties, when grown under shelter tents, are also wrapper varieties.

Soil requirements.—Cigar filler tobacco is best grown in rich alluvial soil. Sandy loam soils along the Cagayan river in the Cagayan Valley, which are inundated regularly, are the best filler tobacco districts of the country. The clay loam soils of the interior valleys of the Ilocos region also produce filler tobacco of good quality.

Climatic requirements.—Regions with short dry periods like the Cagayan Valley are most suitable for cigar filler tobacco. The Ilocos regions with well-defined dry and wet seasons are also filler tobacco producing districts but the crop is always inferior in quality because it is stronger, coarser, and has a tendency to yellow upon curing. While districts of abundant rainfall throughout the year may be adaptable to wrapper tobacco culture, yet for cigar filler tobacco such districts can not be recommended as the resulting crop is likely to be without body, taste (flavor), aroma, or gum—characteristics necessary for good filler.

The optimum seasonal periods of the different field operations for filler tobacco fall about the same as in the case of wrapper tobacco, viz.:

1. Seeding .... September 15th to October 15th.
2. Transplanting .... November 1st to December 30th.
3. First harvest .... January 25th to February 1st.
4. Curing period .... From 25 to 34 days.
5. No. of priming (harvest) .... From 4 to 8 times.
6. Interval of priming .... 10 to 14 days.

Location and preparation of seedbeds.—A higher ground than the regular tobacco field should be selected for seedbeds. It should be rich, loamy, near a water supply, and with good drainage. Virgin lands are most preferable if available. The land should be plowed and harrowed several times in August and September and finally divided into plots of convenient sizes. Between the beds must be paths of about half a meter wide, to serve as drainage at the same time. For convenience in many operations the beds should not be more than 10 meters long and 1.2 meters wide, each provided with inclined tents facing the east to protect the beds from strong sunlight and rain. Before sowing, the beds are finally worked out by garden tools, the soil pulverized and smoothed, and if necessary, sterilized. There are three practical ways of seedbed sterilization, viz.: pouring boiling water on the beds, burning dead vegetation on the beds, and by roasting the top soil on galvanized pans and returning the same to the beds afterwards.

Seeding.—Eight to ten grams of seed mixed with a chupa of wood ash is enough to cover a bed 10 meters long by 1.2 meters wide. The seed mixture is scattered sparsely and evenly over the bed and packed lightly with a wooden plank to keep the seeds firm in the soil. The beds are sprinkled with water to keep the soil moist. Ants usually become a menace during the germination stage as they carry the seeds away. To prevent this, corn meal with little sugar or coconut meal should be scattered around the beds. This bait will keep the ants busy, away from the seeds. A bed with the area mentioned above can readily supply 1,000 seedlings so that a hectare plantation requires no more than 15 seedbeds of good seedlings.

Care of seedlings.—The surface of the beds should be at all times kept moist. The seedlings will come up in seven days under normal conditions and will be quite big enough in 21 days. After 21 days, the tent of the beds can be removed to allow the seedlings to grow in the open. Keep the seedlings free from the weeds, taking care not to disturb them in weeding. By this time, the cutworms will begin to feed upon the tender leaves. To keep the worms under control the beds should be dusted periodically with a calcium arsenate mixture (one part calcium to 16 parts sterilized road dust). An ordinary cheesecloth bag becomes a handy duster merely by filling it with the arsenate mixture and shaking it gently over the seedlings.

Preparation of the field.—The land is first cleared of bushes, stumps and weeds, and then plowed and harrowed thrice before

the furrows are laid out. The furrows should be one meter apart one way and the cross furrows, 70 or 80 cm. apart the other way. The plants are set on every intersection of the furrows so that the planting distances are one meter between the rows and 70 or 80 cm. between the plants in the row.

Transplanting.—The seedlings should be ready for transplanting 54 to 60 days after sowing. Before pulling the seedlings, the beds should be sprinkled with water to soften the soil, thereby effecting less injury to the roots. On sunny days transplanting should be done only in the afternoons but if the weather is cloudy, planting can be done throughout the whole day, beginning early in the morning. By means of a trowel or a small bolo a hole is dug at the intersection of the furrows and the root of the seedling is inserted up to the neck. The root is covered with the surrounding soil and pressed firmly by the hand to brace the stem thereby allowing the seedlings to stand erect. The newly transplanted seedlings should be watered to hasten their recovery. Transplanting once started should not be stopped until the whole field is planted in order to obtain a uniform stand of crop which is very desirable.

Cultivation.—The first cultivation is given when the plants become well established and the second, usually the last, when they are about a foot high. Cultivation is done by passing the plow between the rows and heaping the soil along the rows of plants, thereby forming ridges. After the second cultivation the plants will then be too big to allow the work animal to pass through without breaking the leaves of the plants if these are of vigorous growth; otherwise a third and fourth cultivation may be necessary. The first cultivation should be done criscross, the second and subsequent ones only lengthwise.

Worming.—The picking of worms commences as soon as the plants are set in the field and is continued until the standard leaves are harvested. Since the worms feed mostly on the buds, care should, therefore, be exercised in worming so as not to break the growing points of the buds. Children can easily be taught to do this job properly.

Topping and suckering.—Topping is a necessary operation in cigar filler production and should be performed when the flower head is fully developed. Topping consists of the removal of the flower head by cutting it off with a pocket knife or a bolo. Suckering is a subsequent operation as the production of suckers from the axils of the leaves is stimulated by topping. Suckers

can easily be pinched off by hand when they are still tender; otherwise, when already big, the use of a knife is necessary to avoid injury to the bark of the main stem of the plant.

Seed selection.—Before the topping operation is performed the plantation should be gone over thoroughly to select the plants for seed production purposes. The plants selected should be bagged before the flowers open to insure self-pollination. The bags are removed as soon as the pods are formed. When the capsules are already mature, the whole flower head is cut off, bundled up in bunches and hung in the curing barn to dry. When dried, the capsules are threshed and the seed separated from the hull and stored in air-tight containers for future planting.

Harvesting.—The sand leaves often termed "palaspas" are harvested before the plants are topped. Cigar filler leaves are harvested at a more mature stage than wrapper tobacco. The changing of the color of the entire leaf from deep to light green, the yellowing of the margin and tip, sometimes the drying of the tip, and the conspicuous disappearance of the leaf hairs are some of the indications of maturity. Of course, experience is the safest guide. The leaves are primed, sometimes from four to six leaves being harvested from a plant at one time, and the interval of priming ranges from 10 to 14 days. The harvested crop is carried to the barn either on sleds or carts or wrapped in suitable mattings and carried overhead by men and women.

Poling.—The leaves are first classified as to size and soundness before they are poled on bamboo sticks called "palillos." These are about a meter long with a butt on one end and a sharp point at the other. With one hand holding the leaf and the other hand guiding the sharpened end, the worker guides the sharp end of the "palillos" and pierces the petiole of the leaf ventrally, then folds the leaf blade in such a way that the midrib is exposed. This operation is repeated until the stick is full of leaves. A stick can hold from 80 to 100 leaves, depending upon the size of the leaves and length of the "palillos." This method of poling tobacco is the prevailing system in the Cagayan Valley. The strung tobacco is hung on a rack and exposed to sunshine to wilt for three to five days, after which it is brought into the curing barn where the curing is completed by the action of air.

Curing.—The wilted tobacco is placed upon racks in the curing barn, every stick about a foot apart. By opening the windows and doors of the barn the crop dries gradually by the action of air until it is completely cured. At night, the ventilations are

closed to prevent cold wind and moisture from getting in, and during adverse weather charcoal braziers are built on the dirt floor of the barn to guard against excessive moisture. Curing should be complete in 27 to 34 days under ordinary conditions. A hectare of cigar filler requires a curing barn 12 meters long, 8 meters wide, and 4 meters high.

Fermentation.—A crop ready for fermentation should be thoroughly cured with the midribs well desiccated. The "palillos" are taken down from the racks when they are neither too soft nor too dry, and are piled into "mandalas" (piles of tobacco) for fermentation. The "mandala" is rebuilt 3 to 4 times, at 2 and 3 weeks intervals, to change the position of the crop so that the outer, bottom, and top portions of the pile will also be placed in the interior of the pile. Ordinarily, a crop of 40 quintals is fermented in two months. A good "mandala" for an ordinary crop of 40 to 50 quintals is 3 meters wide and 5 meters long, the height depending upon the quality of the crop. The crop, upon being piled, evolves heat which improves its color, texture and flavor. When the maximum temperature is reached the heat gradually falls and the tobacco is recognized as being thoroughly fermented. The tobacco is then removed from the stick, ready to be classified and bundled into "manojos."

Preparation of product for market.—The tobacco is sorted according to size, soundness, and fineness as per Internal Revenue regulations, bundled into "manojositos" of 100 leaves, and piled again one grade or class after the other. Ordinarily, the cigar filler crop is not baled by the producer, unless he desires to transport the product to distant markets, as representatives of buying firms are always stationed in the tobacco districts ready to buy the crop direct from the farmers.

ILLUSTRATIONS

PLATE 1

FIG. 1. A typical plant of the Pampano, one of the best native varieties for cigar filler leaf tobacco production.

2. A partial view of a cigar filler leaf tobacco plantation of the Viscaya variety. This variety, when grown under partial shade, is also an ideal type for cigar wrapper leaf tobacco production.

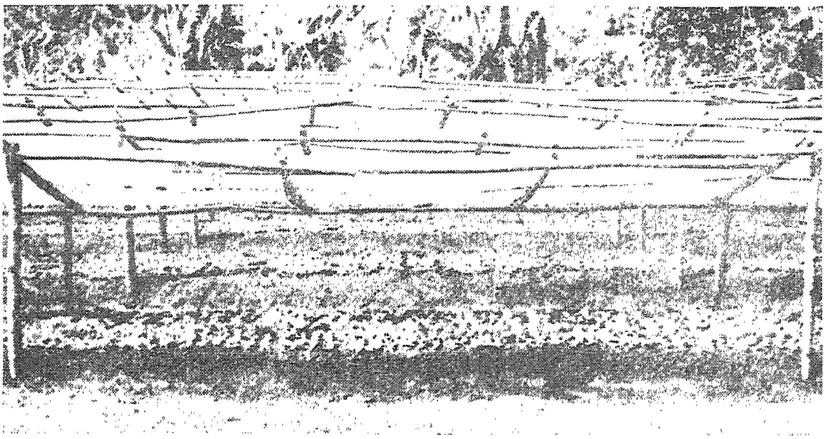
PLATE 2

FIG. 1. Tobacco seedlings of the cigar filler type, 21 days old, at the Los Baños Economic Garden, Los Baños, Laguna. The seedbeds were sheltered by abaca cloth.

2. A model tobacco curing barn for drying cigar filler leaf tobacco, Ilagan, Isabela.

1 2

PLATE 1.



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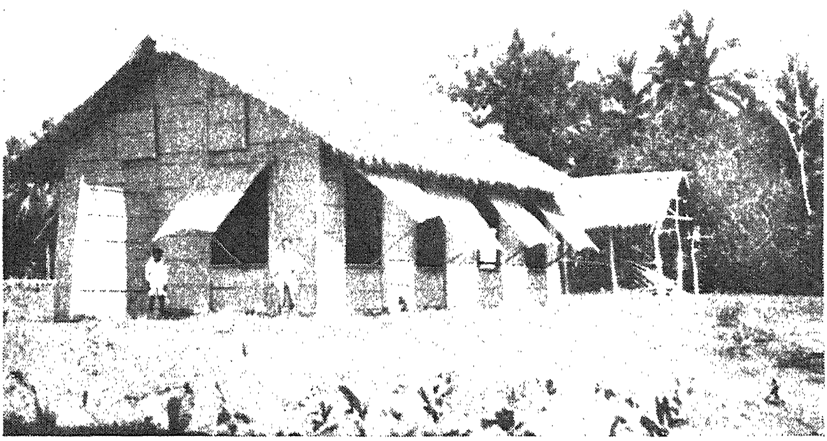

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PLATE 2.

THE CITRUS RIND BORER AND ITS CONTROL

(Farmers' Circular No. 48)

By Catalino E. Garcia

Assistant Agronomist, Bureau of Plant Industry

TWO PLATES

In the Philippines as well as in India, Ceylon, Malaya, and the Mediterranean region the citrus rind borer, *Prays citri* Milliere is one of the most serious pests of the pummelo, sweet orange, lemon, lime, and several other varieties including the wild citrus. The imported pummelo such as the Siamese, and the sweet orange varieties Valencia, Pineapple, Dougat, and others have been observed to be especially susceptible. The native lime has also been observed to be a favorite host.

The insect is destructive especially to young fruits causing them to fall off. The infestation starts after the withering of the petals of the flower, and the falling off of the fruits occurs before they are over 10 millimeters in diameter. Attacked young fruits are yellowish in color and their skin is depressed irregularly. Fruits that survive the attack produce galls or swellings on the rind, as shown in Plate 1, and such fruits are unsightly, often poor in quality and command low prices.

LIFE HISTORY AND HABITS

The moth is grayish brown with both pairs of wings fringed along the hind margin with fine hairs, as shown in Plate 2, Fig. 1. The adult insects are from 3.5 to 4.5 millimeters long, according to sex, and with a wing expanse of from 8 to 10 millimeters.

The female lays its eggs singly on the surface of the flower-buds and fruits, the latter being preferred. The eggs are almost circular in outline, creamy white, flat, like cakes, slightly convex on the upper or free surface and are about 0.5 millimeter in diameter. They turn light brown before hatching. They hatch in from 4 to 5 days, the average being 4.5 days.

On hatching the tiny caterpillar, which is about 1 millimeter long, bores into the rind of the fruit and feeds on the tissues

within. It is creamy white, cylindrical and with a brownish yellow head.

The larva remains within the fruit for 10 to 19 days, or an average of 13 days, after which it comes out. At this stage it is about 3.5 to 5.5 millimeters long and is greenish with brown spots on the lateral sides of each thoracic segment.

Pupation takes place in between overlapping leaves, on the lower surface of the leaf usually near the fruit, on twigs or at times on the fruit itself. The pupa is enclosed by loosely woven white cocoon. The pupa, which is about 4 to 5 millimeters long, is light green in color, but turns dark brown before emerging from the cocoon. It remains in the cocoon from 3 to 5 days, the average being 4 days.

The total span of life of the rind borer, from the laying of the egg to the emergence of the adults, is 17 to 29 days, with an average of 21 days.

During the months of January, February, and March when the pummelo, sweet orange, lemon, and lime are not in bloom or in fruit, the insect breeds on wild citrus, such as "bilolo" (Tagalog), "cabuyao" (Tagalog), and "goronguro" (Pangasinan) as these trees are ever-bearing. As soon as the pummelo, sweet orange, and other commercial species of citrus bloom, the insect migrates to them and lays eggs on their flowers and fruits.

CONTROL MEASURES

The following control measures have been practiced at the Tanauan Citrus Station, Tanauan, Batangas, and have given promising results:

1. *Spraying with derris-soap, prepared according to the following formula:*

Derris powder, fine (about 34 spoonfuls levelful)	120 grams
Soap powder or Chinese laundry yellow soap	300 grams
Water (or about one petroleum canful)	5 gallons

Spraying at weekly intervals, from the time the petals of the citrus flowers fall off until the fruits are about 7 centimeters in diameter in the case of the pummelo, about 5 centimeters in the case of "cajel," and about 2 centimeters in other varieties, was found to aid greatly in reducing the ravages of the pest. The eggs and pupae which are moistened by the spray are killed. The spray should be applied in a fine mist with a hand pump

provided with a long rubber hose and Bordeaux nozzle which are tied to a bamboo extension rod for tall trees. Thorough spraying is necessary, in order to drench the leaves and fruits and thus moisten the eggs and pupae.

2. *By poison bait, according to the following formula:*

Sodium arsenite	20 to 25 grams
Sugar (brown)	400 to 500 grams
Water	5 gallons

The sodium arsenite should first be dissolved in the water after which the sugar should be added and likewise dissolved by stirring with a bamboo or wooden stick. In view of the fact that *sodium arsenite is a violent poison, the hand should not be used in dissolving it and domestic animals should be kept away from the prepared bait. One should see to it also that it is not mistaken for drinking water.* After spraying the hands and equipment should be washed thoroughly. The bait should be applied in the evening by spraying it on the foliage of the citrus trees. The application of the bait should be done at intervals of seven days until the fruits are about 5 centimeters in diameter in the case of "cajel" and about 7 centimeters in the case of the pummelo.

3. *Collection and destruction of infested fruits.*—The young infested fruits that fall to the ground should be collected promptly for every fruit collected means a reduction of the rind borer population. Unless the fallen fruits are promptly collected, the larvæ will soon leave them and pupate on grasses and weeds. The fruits collected should be destroyed either by burying them deep in the ground or putting them for two days in strong soap solution after which they may be disposed of.

4. *By growing certain species of citrus as trap crops, such as Villafranca lemon, "calamondin," and Tahiti lime.*—It has been found out that the insect lays eggs on the fruits of these plants and the larvæ which are hatched from these eggs are abnormally weak and die before coming out of the fruits. Villafranca lemon, "calamondin" and Tahiti lime are, therefore, recommended as trap crops as their fruits are heavily attacked by the rind borer.

5. *Encouraging the multiplication of natural enemies.*—In the Tanauan Citrus Station, Tanauan, Batangas, two natural enemies were observed. One of them is the red ant "hantik," *Oecophylla smaragdina* which makes its nest in the tree and another is a hymenopterous insect which was found to parasitize the

pupa of the pest. The ant protects the fruits from being attacked by the borer. In China, the multiplication of this ant is said to be encouraged by putting the nests in the citrus trees to control a certain kind of leaf-eating insect. The only objection to this method is that it makes the picking of the fruits quite difficult for the ants' bite is painful. The ants also attend to scale insects, such as the green scale, and thus encourage their multiplication. However, if the ants become rather troublesome in this regard, they may be controlled by spraying with soap solution and poisoned syrup.

ILLUSTRATIONS

Plate 1

Citrus fruits attacked by the rind borer.

Fig. 1. Grapefruits
2. Oranges
3. Lemons

Plate 2

The citrus rind borer.

Fig. 1. Adult moth (× 10)
2. Egg (× 10)
3. Larva (× 10)
4. Pupa (× 10)

1 2 3

PLATE 1.

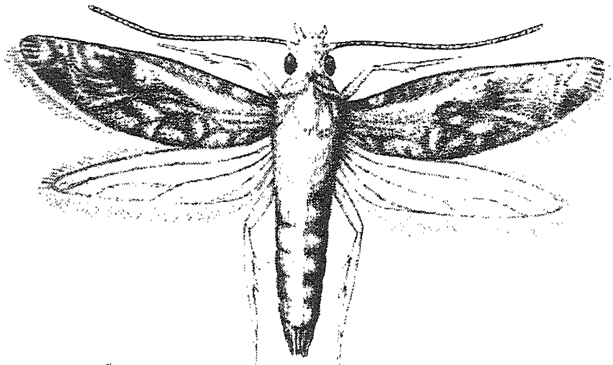

Fig. 1

Fig. 2

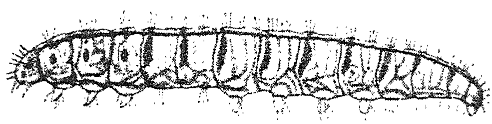

Fig. 3

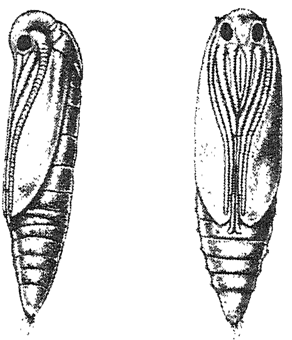

Fig. 4

PLATE 2.

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PROGRESS REPORT ON CITRUS HYBRIDIZATION: PROPAGATION

By JUAN P. TORRES

Of the Bureau of Plant Industry

NINE PLATES

In a previous report,(1) mention was made of the present article. The object of this paper is to portray the extent of the propagation and planting of Philippine citrus hybrids, including the methods of propagation and culture used, which may be applicable to general nursery practices.

REARING HYBRID SEEDLINGS

After the hybrid seedlings had been carefully selected, they were transferred one by one to the pricking boxes. At this stage the seedlings were from three to five months old. In the pricking boxes, they were set wide apart, from 8 to 10 centimeters, so as to maintain them for several months until the weather and nursery conditions became favorable for transplanting. For large scale propagation, pricking plots instead of pricking boxes may be used. The soil for pricking purposes was a sandy loam or loamy garden soil with an equal proportion of well-rotted compost. In the absence of sufficient organic fertilizing materials, a slight dressing of ammonium sulphate or any nitrogenous fertilizer was found to be beneficial to the seedlings. Not infrequently the seedlings under such crowded condition were attacked by citrus canker, so, as a measure of control, the seedlings were sprayed with either lime sulphur spray or Bordeaux mixture

at regular intervals of about once a week. As soon as the hybrid seedlings had reached a height of 40 to 50 centimeters they were set out in the nursery rows. Only the most vigorous ones were selected for planting in the nursery.

Nursery.—The nursery should be located either within or as near as possible the fields where the sedlings are to be transplanted. An adequate supply of water is imperative in successful nursery work. The nursery should be established on level ground with a rich clay loam soil.

In the absence of a suitable level ground, a slight slope may be used provided the nursery beds are terraced, otherwise, it will not do for the purpose. With terraced beds the nursery is not subject to severe erosion during rainy days and the water penetrates into the soil more uniformly and more easily than in unterraced beds.

On any sloping ground the soil is usually clayey and it will easily bake upon drying, forming an impermeable layer on the surface especially during the dry season. When watered, this impermeable layer prevents the penetration of water into the soil. Consequently newly planted seedlings in this kind of soil suffer wilting due to ineffective watering. To overcome such difficulty it becomes expedient to dig around each planted seedling a shallow ditch to facilitate the penetration of water into the soil surrounding the root systems of the newly planted seedlings. The terraces should be made one to one and a half meters wide and of any convenient length depending upon the grade of the ground to be worked.

The selected hybrid seedlings were thus prepared in much the same way as citrus stocks are prepared for planting in the nursery rows. The main root was cut off or pruned back to about 10 to 15 centimeters long so as to encourage a rapid development of strong lateral roots. Some of the leaves were also cut off so as to balance the volume of foliage with the remaining roots. Reduction of foliage may not be necessary if planting is done during the rainy days, but pruning insures good condition of the seedlings should any unexpected inclement weather occur. Afterwards the hybrid seedlings were set out in double or triple rows, about 40 centimeters apart. They were allowed to grow and develop in the nursery until they became large enough for transplanting into the testing fields. At times when the seedlings in the nursery rows were found quite slow in growth it was deemed necessary to apply a light dose of fertilizer, 7 to 10 grams

per plant several months before transplanting. If the application was made during the dry months, which was usually the case, the seedlings were for obvious reasons thoroughly watered just after the application of the fertilizer. Three to 4 small holes were made around each seedling to the depth of the root system and into these holes the required dose was poured. The holes were then covered. In response to the fertilizer treatment the seedlings sent out young shoots and leaves in abundance. These young shoots were allowed to develop fully and to harden before the seedlings were dug up for transplanting.

PROPAGATION

In the propagation of citrus hybrids three methods were employed: by planting the seedlings, by planting budded plants and by top-working some buds on old Batangas mandarin trees. The treatment involved in rearing hybrid seedlings for transplanting has already been discussed in the preceding paragraphs. A new method of propagation which was recently adopted so as to provide each young hybrid seedling with a double root system, is also described elsewhere in this report. This new method is a combination of inarching and tongue grafting as applied to young seedlings for both stocks and scions.(9)

PLANTING

The hybrid seedlings for planting in the trial orchards were carefully selected long before transplanting.(2) They were allowed to attain a height of not less than one meter nor more than 1.5 meters. Seedlings less than one meter high were choked out by weeds and vines and catch crops such as rice, corn, beans, yams and gabi. This will be discussed later in this report under the topic "Large versus small seedlings for planting."

The selected hybrids were balled up after pruning. This was done by removing all branches and twigs on the trunk from the ground to a height of 45 centimeters and allowing the seedlings to develop single trunks. Seedlings more than 1.5 meters high were cut to the proper height. Some of the branches, if too numerous, were removed and the long slender ones cut to suitable lengths in order to maintain a good balance between the top and the root sytem and to encourage the development of a strong well balanced crown.

It is needless to state that the best time for planting citrus is during the early part of the rainy season or any period from

May to August, when there is an abundant natural supply of moisture in the soil. However, during the dry season citrus may be planted if regular watering is possible.

The seedlings and budded plants of different crosses planted are listed in Appendix A and summarized in Table 1.

BUDDING

It was noted that the hybrids from some crosses were too weak to stand adverse conditions in the nursery. Upon closer examination they were found to have very poor root systems. Since these hybrids were too valuable to be discarded at once and were in need of utmost care, they were budded on strong stocks as soon as they had produced some normal buds, so as to give them greater chances of surviving and growing into normal hybrid seedlings. Propagation of hybrid seedlings by budding not only saves the weak hybrid seedlings but also helps in multiplying the selected hybrids for testing and further studies.

The selected normal hybrids were allowed to develop good sized branches and twigs from which scions were prepared. Some of the normal seedlings of the same cross or those of other crosses or any kind of seedlings suitable for budding were used as stocks.

Stocks.—The stems of the stocks may have attained the proper size in budding but if the bark is tight they are not in condition for the process. Failure of the stocks to take in buds would result in the stocks becoming overgrown and wasted. To keep the seedling stocks in vigorous condition and in order to gain time in the production of budded plants the less vigorous seedling stocks may be treated as those seedlings intended for direct transplanting, i. e., each seedling stock with 7 to 10 grams of any nitrogenous fertilizer. When so treated more than 90 per cent of the stocks were found to be ready for budding in four to five weeks time after the application. The method of application has already been described under the topic "Rearing Hybrid Seedlings."

Treatment of overgrown stocks.—Not infrequently many of the stocks which became overgrown were discarded and replaced with younger seedlings. Some nurserymen rejuvenated their stocks by cutting off the stem at a certain height or by lopping it off so as to induce the growth of new shoots as near to the ground as possible. These shoots were reduced to one, and budded as soon as they were in condition.(3 & 4) This process

takes at least three to six months before the stocks become suitable for the next budding operation.

When the stocks are already too large the application of fertilizer may not be advisable and to discard them would surely increase overhead expenses. A new and very practical treatment consisted of watering first the nursery so as to render the soil moist and therefore easy to cultivate. The top layer, about two inches, of the nursery was then converted into a fine tilth and the moist soil was hilled up so as to cover the stems of the seedlings to a height of about six to eight inches and then allowed to stand for sometime. After thirty to forty days all the treated stocks readily took in buds. Evidently the moist soil had softened and loosened the bark tissues rendering the stocks suitable for budding. This practical treatment to loosen the tight bark tissues of the stocks was tried successfully by the writer with no less than two thousand seedling stocks at the Economic Garden and in a private nursery.

Shield-buds.—The usual procedure in slicing the shield-buds is to hold the budstick with its distal end toward the cutter. The writer found it not only more convenient but also more reasonable to hold it in the reverse position, i. e., with its butt end toward the cutter. The claim that the wood would split when held in such a position(3) was not experienced when the knife used in cutting was very sharp. Moreover, in such a position there is a good and easy grip and unlike the usual manner of holding the stocks the buds are far from being hard-pressed by the thumb and in fact the shield-bud thus produced has a cleaner-cut upper portion. Besides, after making a perfect cut the shield-bud may be placed immediately into the incision, whereas in the usual way of holding the budstick the cut shield-bud is first handled by the other hand before it may be inserted into the incision of the stock.

Very frequently, it has been observed in budding, especially citrus, that some of the buds grow and develop into normal budded plants even though the lower portion of the shield-bud is dead provided, however, that the upper portion remains healthy and sound. On the other hand, none of them ever survive once the upper portion of the shields has turned brownish. Obviously, in cutting the buds the upper portion must be given utmost care. It is quite obvious that in the position with the butt end towards the cutter, the upper portion of the shield would have a cleaner cut and its proper length and thickness

could be easily determined since it receives the first stroke of the clean sharp edge of the knife.

Care of budded plants.—The subsequent care of budded plants as to lopping, removal of tops and other nursery routine were carried out in the usual manner. As regards proper pruning, to obtain a strong well developed crown with a single trunk and proper height for transplanting, the same methods were followed as in the case of seedlings for transplanting.

TOP-WORKING OR SHOOT-BUDDING

Apart from the meaning of top-working which is usually resorted to to eliminate undesirable trees or strains from established orchards,(5) by a gradual substitution of tops of these trees with select buds from trees of desirable strains, in this paper top-working means the budding of citrus hybrids on the side shoots or water sprouts of a large citrus tree to hasten the fruiting period of the hybrids. The idea of propagating citrus hybrids by top-working on old Batangas mandarin trees was derived from the previous experience of the writer with some citrus varieties. The writer observed at the Tanauan Citrus Sub-station and in some private orchards that top-worked buds of calamonding, King mandarin, Szinkom mandarin, Washington Navel orange and various other citrus varieties usually commenced fruiting in two to four years after budding, which is a much shorter period than obtainable from planting either the seedlings or the budded plants of the same. With seedlings and budded plants it usually takes one or two years for them to attain their proper size in the nursery and another period of from 4 to 7 years from transplanting to first fruiting. This period depends, principally, upon the variety of citrus scions used and partly upon the kind of stocks employed.

The procedure involved in top-working is to set some buds from the selected hybrid seedlings on the side shoots or water sprouts of a large tree to be top-worked. The condition of the shoots, just as in ordinary stocks must be considered because upon it greatly depends the success of the work. Top-working may be performed with excellent results while the shoots are in active growth with their lower portion assuming a whitish gray color. In this connection it is highly important to use the sprouts of healthy trees. Sprouts 50 centimeters high or a little bit less should be preferred and for obvious reasons those coming from the roots are the most preferred to bud on. Shoot-budding

with citrus hybrids was started in July, 1932 at the Tanauan Citrus Sub-station and in two other private Batangas mandarin orchards.(6) The number and kind of buds successfully grown are listed in Table 2.

LARGE VERSUS SMALL SEEDLINGS FOR TRANSPLANTING

Hybrid seedlings as well as budded hybrid plants were planted for further study and selection work in the trial orchard (Plot No. 15) of the Lipa Coffee-Citrus Station, Lipa, Batangas (Plate 1, Figs. 1 and 2). Also some of the hybrids with the parent varieties in plot No. 16 of the same station. In plot No. 15, 209 plants were planted in June and July, 1933, of which 103 were seedlings and 106 budded plants. The distancing used in plot 15, was 6 meters between rows and 3 meters between plants in the row. In plot 16 the distancing was 6 x 6 meters. Before transplanting the plants measured from 50 to 80 centimeters in height. A census taken one year after planting revealed 13 dead seedlings and 19 dead budded plants or a total of 15.5 per cent. This considerable loss of hybrids within a year after transplanting may be attributed to the small size of the plants at the time of transplanting into the field. Likewise, of the 94 budded hybrids which were also small and which were planted in May and June, 1934, in plot 16 and in the replacement hills in plot 15, 54 plants or 57.4 per cent were found dead after a year. In these two plots many of the citrus plants had been smothered by weeds and covercrops, because they were left neglected for some time for lack of labor. Evidently, the small-sized plants were very sensitive to lack of care. Better results were obtained at the Economic Garden with larger-sized plants, either budded or seedlings.

Los Baños Economic Garden trial orchards.—Two trial orchards of citrus hybrids and varieties were established in adjacent lots at the Economic Garden at Los Baños, Laguna. The first one, Experimental Citrus Orchard No. 1 (Plate 2, Fig. 1) was planted in July and August, 1933 and the second or Experimental Citrus Orchard No. 2, was established in June, 1936. In the first orchard the plants were set at distances of 6 meters quincunx; in the second orchard, at distances of 6 x 6 meters, arranged in squares.

Before planting the seedlings and budded plants were classified with respect to their individual heights into two classes. Those having a height of from 45 to 85 centimeters, averaging about 60

centimeters were classified as small-sized plants; those from 86 centimeters to about 150 centimeters, averaging about 120 centimeters large-sized. The results of observation, a year after transplanting, for three consecutive years are shown in Table 3.

In this connection it must be stated that in 1933 the plants under study had to struggle with a heavy crop of rice from the start and with corn in the latter part of the year. In 1934 there was a heavy growth of weeds including cogon, *Imperata cylindrica* Linn., aguiñgay, *Rottboellia exaltata* L. f., tapilan, *Phaseolus calcaratus* Roxb., and various other weeds. Those planted in orchard No. 2 in 1936 had a catch crop of rice at the start and then corn up to the time the census was taken. The portion of trial orchard No. 2 planted with corn was covered with a very thick growth of aguiñgay, *Rottboellia exaltata* L. f., and other grasses. Apparently due to lack of labor the plants had been subjected to somewhat adverse conditions in the field during their first-year period of establishment.

Results of transplanting large- versus small-sized plants. Los Baños Economic Garden.

Year	Size of plants	Budded or seedlings	Number planted	Number died [a]	Per cent	Average per cent
1933	large	budded	112	7	6.35	
1933	do	seedlings	88	7	7.95	7.00
1933	small	budded	102	54	52.94	
1933	do	seedlings	60	22	36.67	46.91
1934	do	budded	173	92	53.12	
1934	do	seedlings	9	5	55.56	53.29
1936	large	budded	91	4	4.4	
1936	do	seedlings	376	19	5.1	4.9

[a] The counting of the dead plants was made one year after transplanting in every case.

It can be seen from this table that the large-sized plants are better materials for transplanting in the field obviously because they can stand adverse conditions in the field better than the smaller ones.

The question of proper height of seedlings and budded plants in transplanting is important when they are likely to be subjected to the adverse effects of weeds, tall grasses, vines and catch-crops of rice, corn and the like. If cleaning and shallow cultivation around the plants could be maintained regularly so as to eliminate or minimize any adverse field conditions then the planting of small-sized citrus plants, say about 60 centimeters high, could be done without much danger. Of course, continuous

cleaning and cultivation around the plants could be easily done in small scale planting but when done on a large scale, as for instance in commercial planting such field operations would unnecessarily increase the overhead expenses. Planting large-sized plants averaging more than a meter tall but not exceeding 1.5 meters is undoubtedly very advisable in the commercial-scale planting of citrus inasmuch as the large-sized plants can stand adverse field conditions better than the small ones.

RESULTS OF PLANTING HYBRID SEEDLINGS AND BUDDED HYBRIDS

The 49 intraspecific successful crosses and 23 interspecific crosses which were planted were, for record purposes, listed in Appendix A. Also listed are the location of individual plants and the dates of transplanting. Of these 72 different crosses there are under test at present 57 crosses represented by 770 seedlings and 233 budded hybrid plants, as of August 31, 1938. The summary is shown in Table 1. In the trial orchards at Lipa there are at present 72 hybrid seedlings and 115 budded plants; in the Economic Garden at Los Baños 487 hybrid seedlings and 218 budded hybrid plants. Two hundred eleven (211) of the hybrid seedlings were distributed to coöperators for trial planting.

TABLE 1.—*Census of Philippine Citrus Hybrids as of August 31, 1938*

(Summary of Appendix A.)

Crosses	Number of hybrids planted				Number of budded plants planted		
	Lipa	E. G.	Coop.	Total	Lipa	E. G.	Total
1. China × Bat. 8865	none	11	20	31	none	none	none
2. China × King	none	11	5	16	none	none	none
3. China × Tison	none	11	9	20	none	none	none
4. King × Bat. B 87	none	11	none	11	none	8	8
5. King × Bat. 8865	11	4	none	15	17	6	23
6. King × Calamandarin	none	21	11	32	none	none	none
7. King × Dancy	none	10	27	37	none	none	none
8. King × Kishiu	none	30	30	60	none	35	35
9. King × Ladu	none	30	24	54	none	8	8
10. King × Saagkam	none	7	none	7	none	none	none
11. King × Szinkom	none	10	6	16	none	none	none
12. King × Tison	none	9	none	9	none	none	none
14. Kishiu × Bat. K4	none	10	none	10	none	4	4
15. Kishiu × Bat. K 23	none	1	none	1	none	none	none
16. Kishiu × Bat. 8865	none	9	none	9	none	12	12
17. Kishiu × China	none	2	none	2	none	9	9
18. Kishiu × Dancy	none	1	none	1	none	3	3
19. Kishiu × King	none	none	none	none	4	13	17
21. Kishiu × Szinkom	none	none	none	none	2	35	37
22. Ladu × Batangas 8865	none	19	11	30	none	none	none

TABLE 1.—*Census of Philippine Citrus Hybrids as of August 31, 1938*—Ctd.

Crosses	Number of hybrids planted				Number of budded plants planted		
	Lipa	E. G.	Coop.	Total	Lipa	E. G.	Total
23. Ladu × King	none	11	10	21	none	none	none
24. Ladu × Kishiu	none	30	20	50	none	none	none
25. Ladu × Szinkom	none	10	none	10	none	none	none
27. Szinkom × Bat. K4	none	none	13	13	none	none	none
28. Szinkom × Batangas K 23	none	10	none	10	none	none	none
29. Szinkom × Batangas 8865	15	16	none	31	34	29	63
30. Szinkom × China	none	11	10	21	none	none	none
31. Szinkom × King	6	4	none	10	6	7	13
32. Szinkom × Kishiu	none	1	none	1	none	none	none
33. Szinkom × Ladu	none	18	none	18	none	none	none
34. Szinkom × Tison	5	23	none	28	10	none	10
35. Tison × Ladu	none	11	none	11	none	none	none
36. N. Ecija × Siamese 3442	2	26	4	32	none	none	none
37. Panuban × McCarthy	none	1	none	1	none	none	none
38. Pink × La Union	none	none	none	none	2	4	6
39. Pink × Marsh	none	2	none	2	2	2	4
41. Pink × Siamese 3442 p.	none	1	none	1	none	none	none
42. Pink × Siamese 3673 p.	none	1	none	1	1	6	7
44. Siamese 3442 × Marsh	none	2	none	1	none	none	none
45. Siamese × Panuban	1	none	none	1	8	3	11
46. Siamese × Pink	none	4	none	4	5	20	25
47. Siamese × Saigon	10	7	none	17	1	none	1
48. Siamese × Vermillion	13	14	none	27	7	none	7
49. Kussaie × N. Lime	none	4	none	4	none	none	none
51. Calamonding × Ladu	none	20	none	20	none	none	none
52. King × Dougat	none	6	none	6	none	none	none
53. Kussaie × Eureka	none	3	none	3	none	none	none
57. Rough lemon × Sour orange	none	6	none	6	none	none	none
58. Szinkom × Calamonding	none	9	11	20	none	none	none
59. Szinkom × Laurel orange	none	10	none	10	none	none	none
61. Villafranca × Bahia	3	4	none	7	5	none	5
62. Villafranca × Kussaie	none	none	none	none	none	8	8
63. Villafranca × N. Lime	none	1	none	1	none	none	none
64. Villafranca Nat. hybrid	none	1	none	1	none	none	none
65. Villafranca × Nueva Ecija	4	6	none	10	3	none	3
71. Siamese 3442 × Laurel	none	none	none	none	8	6	14
72. Siamese 3673 × King	2	7	none	9	none	none	none

Lipa = Lipa Coffee-Citrus Experiment Station.
E. G. = Economic Garden.
Coop = Cooperative trial planting.

Of the hybrid seedlings and budded hybrids planted in the trial orchards, a few of the Szinkom x Batangas hybrid seedlings planted in 1933 in the Tanauan Citrus Sub-station produced fruits in 1937. The fruits of these hybrid trees were found to be superior in quality to those of the Szinkom parent although in type and general appearance there was a close resemblance. One tree of the Villafranca lemon x N. Ecija pomelo cross (E G I:R11 T7) and another of the Siamese 3442 x N. Ecija

pomelo (E G I:R4 T11) gave each a fruit in 1938. The fruits, however, were lost so their quality could not be determined. Illustrations of some promising hybrids are shown in Plates 7 and 8.

RESULTS OF TOP-WORKING

From Table 2 it can be seen that as of August 31, 1938, the total number of buds on top-worked plants was 292. Fifty buds were grown in the Tanauan Citrus Sub-station; 114 buds in A. T. C. mandarin orchard and 128 buds in A. P. T. mandarin orchard. Both of these two private orchards are located in San Vicente, Sto. Tomas, Batangas. The different crosses that had been top-worked are as follows: China x Batangas, King x Batangas, Kishiu x China, Kishiu x Dancy, Kishiu x King, Kishiu x Szinkom, Ladu x Batangas, Ladu x King, Szinkom x Batangas, Szinkom x King, Pink pomelo x La Union pomelo, 3442 Siamese x Vermillion pomelo, Szinkom x Calamonding and Villafranca lemon x Kussaie lime.

TABLE 2.—*Census of Top-worked Citrus Crosses as of August 31, 1938*

Crosses	Number of buds			
	Tan. C. Station	A. T. C. orchard	A. P. T. orchard	Total
1. China × Batangas	none	none	16	16
4. King × Batangas	none	none	2	2
14. Kishiu × Batangas	none	1	none	1
17. Kishiu × China	1	5	8	14
18. Kishiu × Dancy	none	14	2	16
19. Kishiu × King	4	13	20	37
21. Kishiu × Szinkom	none	29	15	44
22. Ladu × Batangas	none	1	none	1
23. Ladu × King	none	15	7	22
29. Szinkom × Batangas	43	27	49	119
31. Szinkom × King	none	4	none	4
38. Pink × La Union p.	none	2	none	2
48. 3442 × Vermillion p.	2	none	none	2
58. Szinkom × Calamonding	none	2	8	8
62. Villafranca × Kussaie	none	3	1	4
Totals	50	114	128	292

Twelve hybrids of the Szinkom x Batangas cross and one of the Szinkom x King cross top-worked in 1932 and 1933 started fruiting in 1935 and in 1936 (see Table 3). Buds of the Kishiu x China No. 2, Kishiu x King No. 2, Kishiu x Szinkom Nos. 1, 2 and 6, and Kishiu x Dancy No. 1, top-worked in 1934 began fruiting in 1938. The 3442 Siamese x Vermillion hybrid No. 1 top-

worked in March, 1933 flowered in 1936 and fruited in 1937, after its second flowering (only one fruit produced). Evidently, these results show beyond doubt that much had been accomplished in citrus hybridization by budding some buds of the hybrids on the side shoots of old Batangas mandarin trees.

TABLE 3.—*Performance of Top-worked Citrus Hybrids*

Crosses	Hybrid number	Date budded	Station and tree number	Season fruited	Remarks
					Fruits
Szinkom × Batangas	1	8-18-32	T—A18	1938	21
Do	1	8-18-32	T—A22	1936	27
Do	2	8-19-32	T—A19	1935	84
Do	2	8-19-32	T—A20	1936	53
Do	6	8-19-32	T—A24	1935	4
Do	6	3-11-33	T—B60	1936	95
Do	6	9-28-33	T—A89	1936	10
Do	7	8- 5-32	T—B29	1936	140
Do	7	9-28-33	T—W^2—B109	1937	8
Do	8	7-11-32	T—A78	1936	27
Do	8	7-11-32	T—A79	1936	4
Do	9	9-28-33	T—B32	1936	160
Do	9	9-28-33	T—W^1—B109	1938	150
Do	15	9-29-33	T—B202	1938	20
Do	15	9-29-33	T—B209	1938	16
Do	16	9-29-33	T—B238	1938	44
Do	16	9-29-33	T—B162	1936	54
Kishiu × China	2	6-19-34	T—W^1—B67	1938	25
Kishiu × King	2	6-19-34	T—W^3—B67	1938	5
S. S. P. 3442 × Vermillion	1	3-11-33	T—SS—Pom.	1937	1
Szinkom × Batangas	18	9-29-33	APT—8	1938	53
Do	18	9-29-33	APT—7	1938	16
Kishiu × Szinkom	2	4-13-34	APT—22	1938	56
Kishiu × Dancy	1	6- 9-34	APT—29	1938	62
Szinkom × Batangas	4	11-16-32	ATC—37	1937	1,200
Do	4	12- 8-32	ATC—71	1938	425
Do	4	12- 1-32	ATC—65	1938	125
Do	5	11-16-32	ATC—39	1936	25
Do	9	11-16-32	ATC—34	1935	15
Do	10	12- 8-32	ATC—57	1938	7
Do	10	12- 8-32	ATC—50	1938	200
Kishiu × Szinkom	1	6-21-34	ATC—73	1938	98
Do	6	4-13-34	ATC—41	1938	31
Do	6	6-21-34	ATC—94	1938	53
Szinkom × King	6	11-16-32	ATC—43	1935	11

NOTE.—Tanauan Citrus Station; APT—a private orchard; ATC—another private orchard.

Of those top-worked in 1932 that had already fruited for three successive years, Szibat No. 2 (the "Szi" stands for the Szinkom seed parent, the "bat" for Batangas, the pollen parent variety) was found to be very promising. The Szi-bat or Szibat No. 2 is a new variety which is found to be prolific and of better growth habits than the Batangas (Plates 3, 4, 5, & 6, Fig. 1).

In this particular hybrid are combined the strong attachment of the fruits of the Szinkom, the very pleasant flavor and aroma of the Batangas, and the attractive deep or reddish orange color of the fruits when cured. The fruits are oblate in shape and of medium size. About 1,000 budded plants of Szibat No. 2 were distributed to different parts of the Islands besides more than 500 that were propagated and planted in citrus plantations in Calauang, Laguna and Bolbok, Batangas. This new variety, due to its desirable bearing habit, strong attachment and good quality of the fruit, should be used as a substitute for the poor quality Szinkom in commercial citrus plantations.

Another promising Szibat hybrid is No. 15. It was top-worked in September, 1933. It fruited for the first time in 1937. It is now loaded with fruits of better quality and larger size than those of Szibat No. 2. The leaves are also broader. Kishiu x Dancy hybrid No. 1 which was top-worked on June 9, 1934 started fruiting during the 1938–39 season. It is expected that the hybrid will be of higher productivity than the shy bearing Kishiu parent. The growth of the top-worked branch resembles that of the Kishiu. The fruit from Siaver (Siamese 3442 x Vermillion) pomelo was seedy, intermediate in size and shape with a medium-sized nipple on the stem end. The quality is better than that of the Vermillion and the color of the flesh is pink, after the flesh-like color of the Vermillion parent. Unfortunately both top-worked buds died of bark rot.

DOUBLE-ROOT SYSTEM FOR HYBRID SEEDLINGS

The new method of providing the young hybrid seedlings with double-root systems is by inarching combined with tongue grafting.(8) This method may be applied as soon as the hybrid seedlings in the seedflats have reached a height of about 30 to 50 centimeters with stems one-half or two-thirds the size of a lead pencil, i. e., long before they reach the budable stage. The object of this experiment is to determine the effects of a double-root system versus a single-root system upon the vigor and condition of the seedlings. Hybrid seedlings with poor root systems were experimented with.

Procedure.—The seedlings of both the stock and the scion were carefully pulled up from the seedflats and prepared as in ordinary inarching, i. e., by removing part of their bark 3 to 4 centimeters long and part of the woody portion underneath from the stems down to the lowest portion near the origin of the root

systems. The stock was then split downward and the scion upward. As in tongue grafting, the "tongue" of the seedling-scion was inserted into the split of the seedling-stock and then tied firmly to it with a piece of budding tape. Afterwards the combined seedlings were planted in suitable pots. As soon as they were united (it took about a month) the top of the seedling-stock was cut off just above the union, thereby leaving each hybrid seedling used as scion with a double-root system (see Plate 9).

The experiment is hardly three months old at this writing and therefore no results can be shown.

The method which is described in the foregoing paragraphs may be of some practical value in nursery work, especially with many of the polyembryonic types of citrus(7) such as the calamonding, Szinkom, Citranges, Tangeloes, Ladu, lemons and others in which the seedlings produced from seeds are mostly vegetatively propagated or are apogamous seedlings of the seed-parents.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This paper presents some methods used in rearing citrus hybrid seedlings as well as budded plants. The possible advantages derived from cutting the shield-buds with the butt end of the budstick toward the cutter has been explained emphasizing the importance of the upper half portion of the "shield" as compared with the lower half. Various treatments of the young as well as the overgrown seedling stocks for budding have been discussed.

Results of experiments on large- versus small-sized plants for transplanting conducted at the Los Baños Economic Garden a year after date of transplanting showed from 46.91 to 55.6 per cent dead for the small-sized and from 4.4 to 7.9 per cent dead for the large-sized seedlings. These results seem to indicate that the large-sized citrus plants, averaging about 120 centimeters in height are more suitable for commercial transplanting than the small-sized ones, averaging only about 60 centimeters. The large-sized plants obviously can stand adverse field conditions better than the small ones.

Of the 72 different successful crosses consisting of 49 intraspecific and 23 interspecific crosses, 44 intraspecific and 13 interspecific crosses have been planted in the testing orchards of the Lipa Coffee-Citrus Station, Lipa, Batangas and the Economic Garden at Los Baños, Laguna.

The period within which to expect desired results from citrus hybrids top-worked on old Batangas mandarin trees has been greatly shortened.

Inarching combined with tongue-grafting has been resorted to so as to provide some citrus hybrid seedlings with double-root systems. This new method of propagation is of practical value in the propagation of polyembryonic types of citrus such as the calamonding, Szinkom, Ladu, Citranges, Tangeloes, lemons, and other citrus varieties in which most of the seedlings grown from seeds are apogamous or vegetatively propagated from the seed parents.

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APPENDIX A.—*List of Philippine citrus hybrids planted in permanent orchards as of August 31, 1938*

(See Table 1)

	Date planted
A. CITRUS NOBILIS OR MANDARIN CROSSES	
1. China × Batangas 8865:	
10 Sdg., E.G. II: R1T2 to T11	6–17–36
1 Sdg., E.G.P.B. Shed Sec. No. 33	7–17–36
20 Sdg., Coöp. C. Tamisin Sec. 1: R5 T1 to T3; R6 T1 to T7; R7 T1 to T8 and R8 T8	8–12–36
2. China × King:	
10 Sdg., E.G. II: R13 T2 to T11	6–17–36
1 Sdg., E.G.P.B. Shed Sec. No. 13	7–21–36
5 Sdg., Coöp. C. Tamisin Sec. 1 R15 T4 to T8	8–14–36
3. China × Tison:	
10 Sdg., E.G. II: R8 to T11	6–17–36
1 Sdg., E.G.P.B. Shed Sec. No. 14	7–21–36
9 Sdg., Coöp. C. Tamisin Sec. 1 R8 T1 T7	8–13–36
4. King × Batangas: B87:	
10 Sdg., E.G. II: R20 T2 to T11	6–24–36
1 Sdg., E.G.P.B. Shed Sec. No. 26	8–12–36
8 of No. 1 on Sz. E.G. I.; R27 T10 to T15	6–26–36
2 of No. 3 on Sz. E.G. I.; R2 T3 and T4	6–30–36
5. King × Batangas 8865:	
3 Sdg., E.G. I: R12 T13 T14 and T16	7–15–33
1 Sdg., E.G. I: R18 T4	7–20–33
1 of No. 12 on Bm., E.G. I: R13 T2	7–11–33
1 of No. 18 on Sz., E.G. I: R15 T3	7–20–34
1 of No. 21 on Bm., E.G. I: R12 T15	7–11–33
1 of No. 22 on Bm., E.G. I: R12 T7	7–11–33
2 of No. 23 on Bm., E.G. I: R13 T5 and T6	7–11–33
9 Sdg., L15: R4 T1; 2, 5, 6, 9, 10, 12, 13–14	6–28–33
2 Sdg., L15: R5 T7 and R11 T13	7–14–33
3 of No. 22 on Bm., L15: R10 T1, 2 and 3	6–20–33
4 of No. 23 on Bm., L15: R10 T5, 6, 7 and 8	6–20–33
2 of No. 21 on Bm., L15: R10 T15 and R11 T12	7–14–33
3 of No. 11 on Bm., L15: R11 T1, 2 and 4	6–27–33
1 of No. 12 on Bm., L15: R11 T5	6–20–33
2 of No. 23 on Bm., L16: R10 T11 and 13	6–19–33
2 of No. 2 on Bm., L16: R10 T15 and T16	6–19–33
6. King × Calamandarin:	
10 Sdg., E.G. II: R2 T2 to T11	6–13–36
10 Sdg., Border II: R12 to R21 T12	6–20–36
1 Sdg., E.G.P.B. Shed Sec. No. 30	7–17–36
11 Sdg., Coöp. C. Tamisin Sec., I R14 T1 to T8 and R15 T1 to T3	8–15–36

	Date planted
7. King × Dancy:	
9 Sdg., E.G. II: R21 T2 to T5 T7, 9 and 11	6–23–36
1 Sdg., E.G.P.B. Shed Sec. No. 24	8–12–36
27 Sdg., Coöp. C. Tamisin Sec. II R1 T11 to T15; T3 T1 to T12; R4 T1 to T10	9– 2–36
8. King × Kishiu:	
29 Sdg., E.G. II: R1 T2 to T11	6–13–36
II Border R10 to R17 and R19 T1s.	6–26–36
E.G. II: R15 T2 to T11	8–18–36
1 Sdg., E.G.P.B. Shed Sec. No. 29	7–17–36
30 Sdg., Coöp. C. Tamisin Sec. I R1 T1 to T7; R3 T1 to T7; R4 T1 to T7 and R5 T6 to T7	8–11–36
3 of No. 19 on Bm., E.G. I: R17 T5, R18 T12 and R20 T15	7– 9–37
2 of No. 29 on Bm., E.G. I: R11 T3 and T10	7– 1–36
1 of No. 29 on Bm., E.G. I: R20 T16	7– 9–37
5 of No. 29 on Bm., E.G. I: R23 T1, 3, 5, 7 and 9	7– 9–37
2 of No. 56 on Bm., E.G. I: R4 T1 and R11 T13	7– 1–36
5 of No. 56 on Bm., E.G. I: R19 T6, 9, 12, and 14; R24 T16	7– 9–37
4 of No. 56 on Bm., E.G. I: R9 T5 R25 T13 and R29 T1 and 8	7– 9–37
8 of No. 58 on Bm., E.G. I: R15, T5, 6 and 8; R16 T1, 6, 9, 14 and 15	7– 1–36
3 of No. 58 on Bm., E.G. I: R10 T1, 5 and 7	7– 9–37
2 of No. 59 on Bm., E.G. I: R22 T8 and 13	7– 9–37
9. King × Ladu:	
10 Sdg., E.G. II: R5 T2 to T11	6–16–36
10 Sdg., E.G. II: R20 T2 to T11	6–25–36
10 Sdg., II Border R1 to R3 to R11 R12	6–26–36
24 Sdg., Coöp. C. Tamisin Sec. I R18 T5 to T8; R19 T1	—
to T8; R20 T3 to T8 plus 6 extra	8–17–36
8 of No. 14 on Sz., E.G. II: R3 T7; R4 T8; R28 T2, 4, 6 and 7; R29 T12	7– 9–37
10. King × Saagkam:	
6 Sdgs., E.G. II: R19 T5, 7 to 11	6–24–36
1 Sdg., E.G.P.B. Shed Sec. No. 21	7–21–36
11. King × Szinkom:	
9 Sdgs., E.G. II: R6 T2 to 4 and T6 to 11	6–16–36
1 Sdg., E.G.P.B. Shed Sec. No. 31	7–17–36
6 Sdgs., Coöp. C. Tamisin Sec. 1 R13 T1 to T6	8–14–36
12. King × Tison:	
9 Sdgs., E.G. II: R3 T2 to 6 and T8 to 11	6–16–36
13. Kishiu × Batangas B87:	
6 Sdgs., Still in the nursery (8–31–38).	
14. Kishiu × Batangas K4:	
9 Sdgs., E.G. II: R23 T2 to 5; T7 to 11	6–24–36
1 Sdg., E.G.P.B. Shed Sec. No. 34	8–12–36
4 of No. 4 on Sz. Coöp. C. Tamisin Sec. II: R1 T1 to 14	9–21–36

	Date planted
15. Kishiu × Batangas K23:	
1 Sdg., E.G.P.B. Shed Sec. No. 35	8–12–36
16. Kishiu × Batangas 8865:	
9 Sdgs., E.G. II: R22 T2, 4 to 11	6–24–36
3 of No. 2 on Sz., E.G. I: R12 T10 to 12	5–15–34
1 of No. 3 on Sz., E.G. I: R13 T9	5–15–34
4 of No. 2 on Sz., E.G. I: R24 T10, 11, 13 and 14	6–20–36
6 of No. 3 on R1, E.G. I: R25 T2, 3, 9, 11, 12 and 16	6–20–36
R26 T17	6–20–36
1 of No. 3 on R1, E.G.P.B. Shed Sec. No. 22	7–21–36
17. Kishiu × China:	
2 Sdgs., E.G. I: R17 T9 and R18 T9	7– 1–36
2 of No. 1 on R1, E.G. I: R10 T3 and 4	5–15–34
5 of No. 1 on Sz., E.G. I: R28 T9, 10, 12, 13 and 16	6–26–36
2 of No. 3 on RL, E.G. I: R11 T5 and R12 T15	5–15–34
18. Kishiu × Dancy:	
1 Sdg., E.G. I: R22 T16	7– 1–36
3 of No. 1 on Sz., E.G. I: R12 T6, 8 and 9	5–15–34
19. Kishiu × King:	
1 of No. 1 on Cm., E.G. I: R5 T10	5– 4–34
1 of No. 3 on R1, E.G. I: R12 T2	6–15–34
3 of No. 4 on RL, E.G. I: R2 T8, T3 T10 and R4 T4	5– 4–34
4 of No. 5 on Sz., E.G. I: R15 T1 to 4	5–28–34
1 of No. 6 on Sz., E.G. I: R15 T7	5–28–34
1 of No. 6 on Sz., E.G. I: R16 T7	7– 1–36
2 of No. 6 on Sz., E.G. I: R23 T10 and T15	6–30–36
2 of No. 5 on Sz., L. 15; R4 T3 and T3	5–26–34
2 of No. 6 on Sz., L. 15; R8 T13 and R9 T15	5–26–34
20. Kishiu × Ladu:	
22 Sdgs. Still in seed flat.	
21. Kishiu × Szinkom:	
5 of No. 1 on Sz., E.G. I: R18 T2, 3, 5, 6, and 7	6–30–36
5 of No. 3 on RL; E.G. I: R26 T9, 10, 11, 14 and 15	6–26–36
3 of No. 3 on RL, E.G. I: R8 T14 and T9 T13 and T14	5–15–34
1 of No. 3 on RL, E.G. I: B Shed Sec. No. 37	8–12–36
3 of No. 5 on RL, E.G. I: R10 T10 to 12	8–12–36
3 of No. 9 on Sz., E.G. I: R15 T9, 11 and 12	5–28–34
1 of No. 7 on Sz., E.G. I: R16 T8	5–28–34
2 of No. 8 on Sz., E.G. I: R17 T2 and T4	5–28–34
7 of No. 3 on Sz., RL, Coöp. C. Tamisin III: R2 T1 to T7	9–21–36
2 of No. 6 on Sz., Coöp. C. Tamisin III: R3 T1 and T2	9–21–36
1 of No. 4 on Sz., L15; R10 T4	5–26–34
1 of No. 10 on Sz., L16 R15 T14	6–19–34
22. Ladu × Batangas 8865:	
10 Sdgs., E.G. I: R9 T2 T11	6–17–36
9 Sdgs., Border II: R1 to R9 T1s	6–26–36
1 Sdg., E.G.P.B. Shed Sec. No. 15	7–31–36
11 Sdgs., Coöp. C. Tamisin I: R9 T3 to T8 T10 T1 to T5	8–13–36

Date planted

23. Ladu × King:
    - 10 Sdgs., E.G. II: R10 T2 T11 6–17–36
    - 1 Sdg., E.G.P.B. Shed Sec. No. 20 7–21–36
    - 10 Sdgs., Coöp. C. Tamisin I: R12 T1 to T8 and R13 T7 and T8 8–14–36
24. Ladu × Kishiu:
    - 10 Sdgs., Types A, E.G. II: R24 T2 T11 6–24–36
    - 10 Sdgs., Types B, E.G. II: R14 T2 to T11 6–18–36
    - 10 Sdgs., Types C, E.G. II: R25 T2 to T11 6–25–36
    - 20 Sdgs., Mixed types, Coöp. C. Tamisin (7 type A. I: R16 T1 to T7) 8–15–36
    - (9 type B. I: R16 T8; R17 T1 to T8) 8–15–36
    - (4 type C. I: R18 T1 to T4) 8–15–36
25. Ladu × Szinkom:
    - 10 Sdgs., E.G. II: R27 T2 to T11 6–25–36
26. Saagkam × Tison:
    - Only 1 plant in the nursery (8–25–38).
27. Szinkom × Batangas K4:
    - 13 Sdgs., Coöp. C. Tamisin II: R2 T1 to T13 .... 9– 2–36
28. Szinkom × Batangas K23:
    - 10 Sdgs., E.G. II: R18 T2 to T11 6–24–36
29. Szinkom × Batangas 8865:
    - 14 Sdgs., E.G. I: R5 T1, 2, 4, to 9, R6 T3 to 8 7–10–33
    - 2 Sdgs., E.G. I: R14 T13 and 14 7–20–33
    - 15 Sdgs., L15: R5 T14 to 15; R9 T9 and 10 and R12 T8 6–21–33
    - 10 of No. 2 on Bm., E.G. I: R2 T2; R6 T1; R7 T5; R8 T9; R9 T16; R11 T4, 6 and 13; R13 T14 and K16 T12 6–25–37
    - 6 of No. 2 on Bm., E.G. I: R15 T14 and 16; R13 T2...... II: R4 T12 R6 T5 ad R22 T3 10–30–36
    - 1 of No. 3 on Bm., RH. Sec. No. 2 7–18–33
    - 2 of No. 13 on Bm., E.G. I: R4 T2 and 3 7–10–33
    - 2 of No. 16 on Bm., E.G. I: R4 T5 and 6 7–10–33
    - 2 of No. 28 on Bm., E.G. I: R4 T7 and 8 7–10–33
    - 2 of No. 22 on Bm., E.G. I: R14 T1 and 4 7–20–33
    - 3 of No. 26 on Bm., E.G. I: R14 T6, 7 and 10 7–20–33
    - 1 of No. 28 on Bm., E.G. I: R14 T12 7–20–33
    - 2 of No. 1 on Bm., L15: R12 T6 and 7 6–20–33
    - 2 of No. 2 on Bm., L15: R10 T9 and 10 6–20–33
    - 3 of No. 3 on Bm., L15: R10 T12 to 14 6–27–33
    - 1 of No. 7 on Bm., L15: R9 T13 6–27–33
    - 4 of No. 8 on Bm., L15: R9 T14 and 15; R12 T9 and 11 6–21–33
    - 3 of No. 8 on Or. L15: R12 T10, 12 and 13 6–21–33
    - 4 of No. 12 on Bm., L15: R13 T1 to T4 6–20–33
    - 2 of No. 13 on S.D., L15: R12 T3 6–28–33
    - 1 of No. 7 on Bm., L15: R14 T13 6–20–33
    - 1 of No. 12 on Bm., L15: R13 T13 6–20–33
    - 2 of No. 15 on Bm., L15: R14 T9 and 10 6–20–33
    - 4 of No. 16 on Bm., L15: R14 T5 to T8 6–20–33
    - 3 of No. 26 on Bm., L15: R13 T9, 10 and 12 6–20–33
    - 2 of No. 28 on Bm., L15: R13 T6, and T8 6–20–33

	Date planted
30. Szinkom × China:	
10 Sdgs., E.G. II: R11 T2 to T11	6–17–36
1 Sdg., E.G.P.B. Shed Sec. No. 18	7–21–36
10 Sdgs., Coöp. C. Tamisin II: R1 T1 to T10	9– 2–36
31. Szinkom × King:	
3 Sdgs., E.G. I: R9 T2 to T4	7–10–33
1 Sdg., E.G.P.B. Shed Sec. No. 16	7–21–36
6 Sdgs., L15: R7 T14 and 15, R8 T14 and 15; R11 T14 and 15	6–26–33
4 of No. 7 on Sz., E.G. II: R17 T10; R19 T6; R21 T6 and R23 T6	7– 9–37
1 of No. 34 on Bm., E.G. I: R15 T10	7– 8–33
2 of No. 4 on Sz., E.G. II: R19 T3 and T4	7– 9–37
3 of No. 19 on Bm., L15: R9 T1, 3 and 4	6–20–33
3 of No. 25 on Bm., L15: R9 T6 to T8	6–20–33
32. Szinkom × Kishiu:	
1 Sdg., E.G.P.B. Shed Sec. No. 23	8–12–36
33. Szinkom × Ladu:	
10 Sdgs., E.G. II: R12 T2 to T11	6–17–36
7 Sdgs., Border II: R22 to R28 T12s	6–26–36
1 Sdg., E.G.P.B. Shed Sec. No. 17	7–21–36
34. Szinkom × Tison:	
22 Sdgs., E.G. I: R7 T1 to T9 R8 T1 to T8; R9 T6 to T9	7–10–33
R16 T10	5–28–34
1 Sdg., E.G. H. R. Sec. No. 1	7–18–34
5 Sdgs., L15: R7 T9 to 13	6–28–33
4 of No. 2 on Aegle, L15: R8 T5 to T8	6–28–33
3 of No. 9 on Bm., L15: R8 T1, 2 and 4	6–28–33
3 of No. 19 on N.E. x 3442, L15: R8 T10 to T12	6–28–33
35. Tison × Ladu:	
10 Sdgs., E.G. II: R16 T2 T11	6–24–36
1 Sdg., E.G.P.B. Shed Sec. No. 19	7–21–36

B. Citrus Maxima or Pomelo Crosses

36. Nueva Ecija × 3442 Siamese:	
25 Sdgs., E.G. I: R4 T9 to T11; R5 T11 to T13; R6 T9 to T13; R7 T10 to 14; R8 T– to T13 and T15; R9 T10, 11, 12 and T15	7–10–33
1 Sdg., E.G. Sec. No. 3	7–18–33
2 Sdg., L15: R3 T1 and T4	6–29–33
4 Sdg., Coöp. J. Samosa, Tanauan, Batangas	7–15–33
37. Panuban × McCarthy:	
1 Sdg., E.G. I: R19 T13	7–20–33
38. Pink × La Union:	
2 of No. 2 on Pink, E.G. I: R25 T10 and 14	5–29–34
1 of No. 2 on S. O., E.G. I: R26 T16	5–29–34
1 of No. 2 on 3442 x Pink, E.G. I: R28 T11	5–29–34
2 of No. 2 on S. O., L15: R6 T1 and T9	5–26–34

	Date planted
39. Pink pomelo × Marsh grapefruit:	
2 Sdgs., E.G. I: R14 T18 and T19	7- 1-33
2 of No. 2 on 3442 x Pink, E.G. I: R28 T14 and T15	5-29-34
2 of No. 1 on S. O., L15: R14 T11 and T12	5-26-34
40. Pink pomelo × Panuban grapefruit:	
All six seedlings produced were weak and discarded.	
41. Pink pomelo × 3442 Siamese pomelo:	
1 Sdg., E.G. Ext. R4 T11	5-30-34
42. Pink pomelo × 3673 Siamese pomelo:	
1 Sdg., E.G. I: R29 T3	5-29-34
1 of No. 1 on S. O., E.G. I: R27 T9	5-29-34
1 of No. 1 on S. O., L15: R15 T4	5-26-34
1 of No. 2 on 3442 × Pink, L15: R15 T7	5-26-34
2 of No. 2 on 3442 × Pink, E.G. Ext. R1 T10 and T14	5-30-34
1 of No. 4 on Pink × 3673, E.G. Ext. R1 T16	5-30-34
43. 3442 Siamese pomelo × Duncan grapefruit:	
All the 3 plants planted (6-19-34) in Lipa plot 15 died.	
44. 3442 Siamese × Marsh grapefruit:	
2 Sdgs., E.G. Ext.: R2 T8 and T10	5-30-34
45. 3442 Siamese × Panuban grapefruit:	
1 Sdg., L15: R14 T3	5-26-34
1 of No. 1 on S. O., E.G. I: R27 T16	5-29-34
1 of No. 1 on S. O., L15: R6 T14	5-26-34
3 of No. 4 on 3442 Panuban L16: R14 T8 to T10	6-19-34
3 of No. 5 on 3442 Panuban L16: R15 T4 to T6	6-19-34
1 of No. 1 on S. O., L16: R13 T7	6-19-34
2 of No. 41 on S. O., E.G. Ext.: R1 T4 and T6	5-30-34
46. 3442 Siamese × Pink pomelo:	
3 Sdgs., E.G. I: R19 T2, 11 and T15	6-30-36
1 of No. 2 on S. O., E.G. I: R25 T15	5-29-34
2 of No. 3 on 3442 × Pink, E.G. I: R26 T12 to T13	5-29-34
1 of No. 2 on S. O., L15: R2 T6	5-26-34
1 of No. 3 on 3442 × Pink, L15: R3 T11	5-26-34
3 of No. 1 on S. O., L16: R14 T5, 7 and 13	6-19-34
1 of E.G. Ext. R4 T11	5-30-34
1 of No. 1 on Pom. E.G. Ext. R2 T11	5-30-34
2 of No. 1 on S. O., E.G. Ext. R2 T14 and 15	5-30-34
3 of No. 4 on 3442 × Pink E.G. Ext.: R3 T2, 3 and 4	5-30-34
3 of No. 6 on 3442 × Pink, E.G. Ext.: R3 T5, 7 and 8	5-30-34
3 of No. 7 on 3442 × Pink E.G. Ext.: R3 T10, 12 and 13	5-30-34
4 of No. 10 on 3442 × Pink, E.G. Ext.: R4 T1, 3, 6 and 7	5-30-34
47. 3442 Siamese × Saigon pomelo:	
7 Sdgs., E.G. I: R19 T1, 3, 4, 7, 8 and T10	7-20-33
10 Sdgs., L15: R1 T14; R2 T1, 3, 4, 9 to T14	6-21-33
1 of No. 4 on N. E. × 3442, L15: R6 T11	6-21-33

	Date planted
48. 3442 Siamese × Vermillion pomelo:	
14 Sdgs., E.G. I: R20 T1 to T14	7–21–33
13 Sdgs., L15: R1 T1 to T15, R15 T1 to T3	6–27–33
1 of No. 9 on S. O., L15: R6 T2	6–27–33
3 of No. 10 on S. O., L15: R6 T3 to T5	6–27–33
2 of No. 11 on S. O., L15: R6 T6 and T7	6–27–33
1 of No. 14 on S. O., L15: R6 T8	6–27–33
49. Kussaie × Native lime—*C. aurantifolia* cross:	
4 Sdgs., E.G.P.B. Shed Sec. Nos. 5, 7, 8 and 25	8–12–36

C. Interspecific Crosses

50. Calamonding × Szinkom—*C. mitis* Blanco × *C. nobilis* Lour

Hybrids hard to distinguish from apogamous seedlings, thus all were discarded.

51. Calamonding × Ladu—as above.	
10 Sdgs., E.G. II: R29 T2 to T11	6–25–36
10 Sdgs., Border II: R20 to R29 T1s	6–26–36
52. King × Dougat orange—*C. nobilis* Lour × *C. sinensis* Osbeck:	
6 Sdgs., E.G.P.B. Shed Sec.	7–16–37
53. Kussaie lime × Eureka lemon—*C. aurantifolia* × *C. limonia:*	
3 Sdgs., E.G.P.B. Shed Sec. Nos. 1 to 3	8–12–36

54. Kussaie lime × Rough lemon—same as above:
All the 7 hybrid seedlings produced died of citrus canker in the nursery.

55. Ladu × Laurel orange—*C. nobilis* Lour × *C. sinensis:*
The seedlings are still small (8–31–38)

56. Magnun ronum × Rough lemon—*C. sinensis* × *C. limonia:*
Out of 27 seedlings 24 had survived and only 10 remained in the nursery (8–31–37).

57. Rough lemon × Sour orange—*C. limonia* × *C. aurantifolia:*	
6 Sdgs., E.G. II: R28 T3, 5, 8 to 11	6–25–36
58. Szinkom × Calamonding—*C. nobilis* Lour × *C. mitis:*	
7 Sdgs., E.G. II: R4 T2 to T7, 9 and 10	6–18–36
2 Sdgs., E.G.P.B. Shed Sec. No. 6 and 9	6–12–36
11 Sdgs., Coöp. C. Tamisin Sec. I R9 T3 to T8 and R10 T1 to T5	8–13–36
59. Szinkom × Laurel orange—*C. nobilis* Lour × *C. sinensis:*	
9 Sdgs., E.G. II: R17 T2 to T9 and T11	6–24–36
1 Sdg., E.G.P.B. Shed Sec. No. 32	7–17–36

Date planted

60. Szinkom × Rough lemon—*C. nobilis* × *C. limonia:*
   8 seedlings in the nursery (8–25–38).

61. Villafranca × Bahia orange—*C. limonia* × *C. sinensis:*
   4 Sdgs., E.G. I: R11 T12, 14, 15 and 16 7–11–33
   1 Sdg., L15: R3 T13 6–28–33
   2 Sdgs., L15: R13 T14 and T15 7–14–33
   5 of No. 3 on Florida orange, L15: R7 T1 to T5 6–27–33

62. Villafranca × Kussaie—*C. limonia* × *C. aurantifolia:*
   2 of No. 12 on pomelo, E.G. I: R15 T15 and R18 T8 5–28–34
   1 of No. 21 on S. O., E.G. I: R18 T10 5–28–34
   2 of No. 19 on S. O., E.G. I: R23 T11 and T12 5–29–34
   3 of No. 21 on pomelo, E.G. I: R23 T13 and T14, R24 T9 5–29–34

63. Villafranca × Native lime—*C. limonia* × *C. aurantifolia:*
   One seedling planted in pot as of 8–31–37

64. Villafranca natural hybrids with pomelo:
   1 of No. 1 on 3442 × Pink E.G. I: R24 T12 5–29–34

65. Villafranca × N. Ecija pomelo—*C. limonia* × *C. maxima:*
   6 Sdgs., E.G. I: R11 T1, 2, 7, 8, 9 and 11 7–11–33
   2 Sdgs., E.G. I: R16 T11 and 13 7–21–33
   4 Sdgs., L15: R3 T5 to R8 6–29–33
   3 of No. 21 on pomelo, L5: R7 T6 to T8 6–27–33

66. Villafranca × R. lemon:
   Only one remaining in the nursery (8–31–38).

67. Washington Navel × Laurel orange:
   Out of 20 only 3 remained in the nursery (8–31–38).

68. 3442 Siamese × Dougat orange—*C. maxima* × *C. sinensis:*
   32 Sdgs. in the nursery near P. B. Shed (8–31–38).

69. 3442 Siamese × Du Roi—as above:
   24 Sdgs. in the nursery P. B. Shed (8–31–38).

70. 3442 Siamese × Florida S. orange—*C. maxima* × *C. aurantifolia:*
   Of the 42 seedlings in the nursery planted 6–23–35 only 9 survived as of 8–25–38

71. 3442 Siamese × Laurel orange—*C. maxima* × *C. sinensis:*
   4 of No. 1 on 3442 × Laurel orange, L16: R15 T7 to T10 6–19–34
   2 of No. 2 on 3442 × Laurel orange, L16: R14 T11 and T12 6–19–34
   3 of No. 2 on 3442 × Laurel E.G. Ext.: R1 T7, 8 and 9 5–30–34
   1 of No. 3 on S. O., E.G. I: R24 T15 6–19–34
   2 of No. 6 on Sz., E.G. O: R14 T11 and T15 5–15–34
   3 of No. 30 on S. O., L16: R15 T11 to T13 6–19–34

	Date planted
72. 3673 Siamese × King—*C. maxima* × *C. nobilis:*	
7 Sdgs., E.G. I: R10 T6, 8, 9 and T13	7–11–33
R17 T6 to T8	7–20–33
2 Sdgs., L15: R3 T19 and T12	6–28–33

NOTE: E.G.I. = Economic Garden Trial Orchard No. 1.
E.G.P.B. Shed Sec. = Economic Garden Plant Breeding Shed Section.
Coop. = Cooperative trial planting.
Sdgs. = Seedlings.
L15. = Lipa Plot No. 15.
Bm. = Batangas mandarin.
Sz. = Szinkom.
R5 T1 = Row 5 hill No. 1.
Rl or R1 = Rough lemon.
Border II = Border of Trial Orchard No. 2.
S O: = Sour orange.

ILLUSTRATIONS

PLATE 1

FIG. 1. Partial view of the citrus hybrid trial orchard, plot 15, Lipa Coffee-Citrus Station, Lipa, Batangas.

2. Another partial view of plot 15.

PLATE 2

FIG. 1. Partial view of Experimental Citrus Orchard No. 1, Economic Garden, Los Baños, Laguna.

2. Left, Kishiu mandarin, notable for its excellent crown but a shy bearer; right, Szinkom mandarin loaded with fruits. Photographed 1931. Tanauan Citrus Station, Tanauan, Batangas.

PLATE 3

Szibat (Szinkom × Batangas) hybrid No. 2, top-worked in August, 1932. Began fruiting in 1935. Note the improved crown. See also Plate 8.

PLATE 4

FIG. 1. A closer view of a branch of Szibat hybrid No. 2 (see Plate 3).

2. Szibat hybrid No. 15. Top-worked on September 29, 1933, began fruiting in 1937.

PLATE 5

Fruits of different varieties. *1.* Szinkom, *2.* Batangas, and *3.* Szibat hybrid No. 2.

PLATE 6

FIG. 1. Szibat hybrid No. 13 on Bm. stock, planted June, 1933. Note the broad leaves in contrast to the narrow leaves of the Szinkom seed parent.

2. King mandarin on Bm. stock in second bearing, with 139 fruits. A very promising variety for commercial planting.

PLATE 7

FIG. 1. King–Batangas hybrid No. 11 on Bm. stock. Planted June, 1933. Tanauan Citrus Station, Tanauan, Batangas.

2. King–Kishiu hybrid No. 56 on Bm. stock. Planted July 1, 1936. Economic Garden, Los Baños, Laguna.

PLATE 8

FIG. 1. Kishiu–King hybrid No. 2, top-worked on Bm. stock June 19, 1934. Fruited in 1938. Note the characteristic improved crown of the Kishiu parent.

2. Szinkom–Tison hybrid No. 9 on Bm. stock, planted June, 1933. Flowered in 1938. No fruit yet. Note the improved crown.

PLATE 9

FIG. 1. A 5-year-old King mandarin orchard, distanced 4.5 meters in the rows, with ipil-ipil, *Leucaena glauca* L., for covercrop.

2. Left, seedlings with double-root systems; right, seedlings with single-root systems.

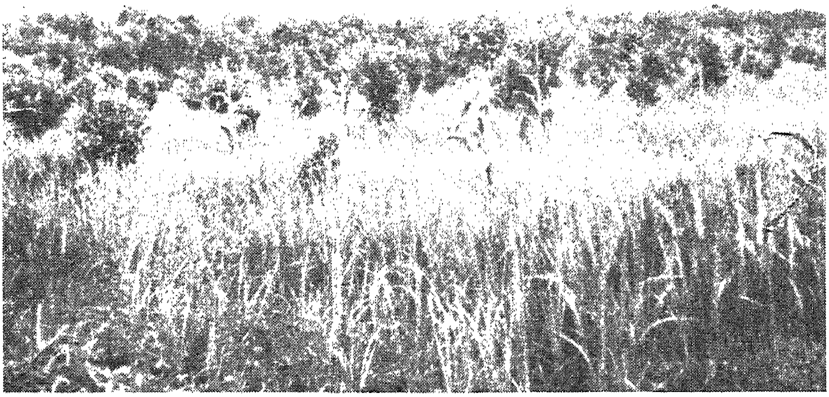

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PLATE 1.

1

2

PLATE 2.

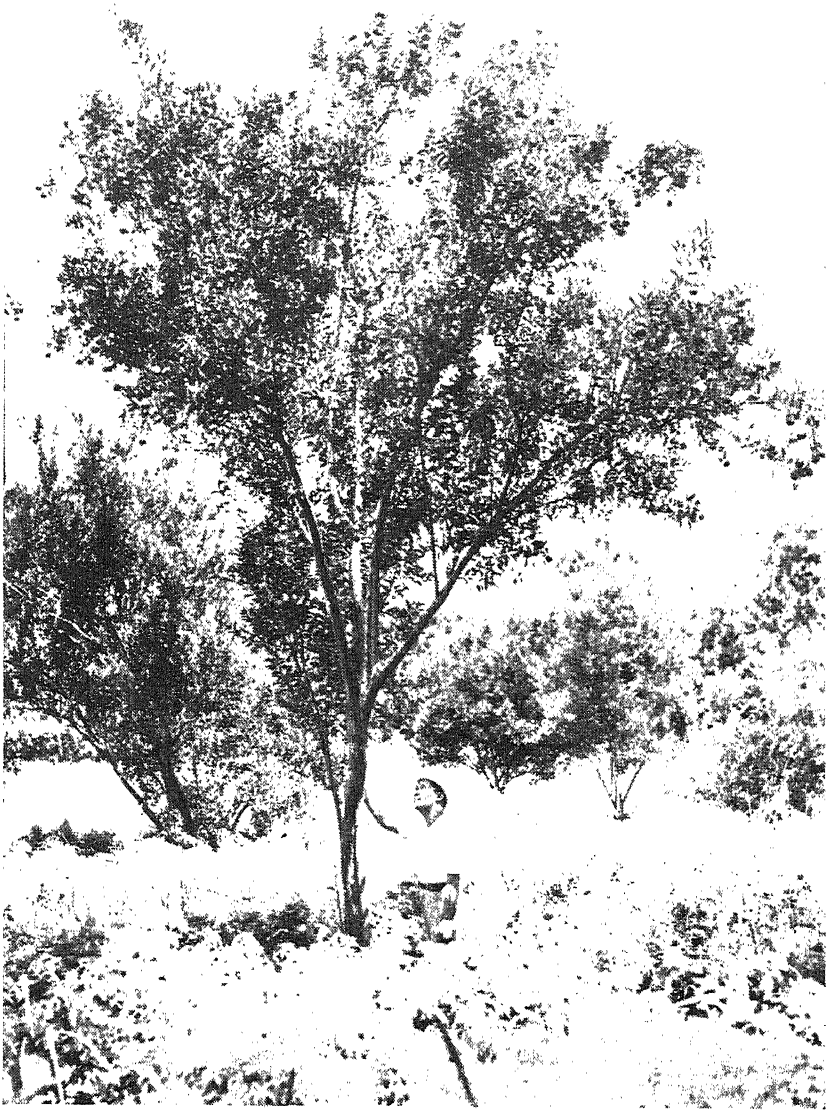
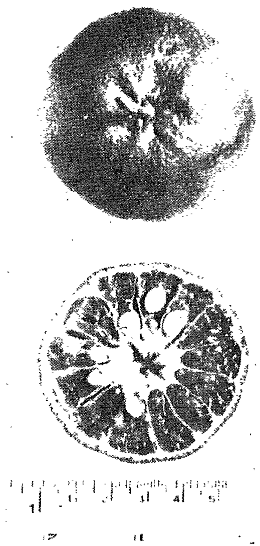


PLATE 3.

1

2

PLATE 4.



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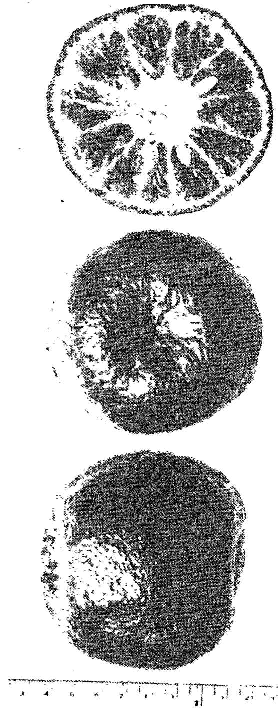

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PLATE 5.

1

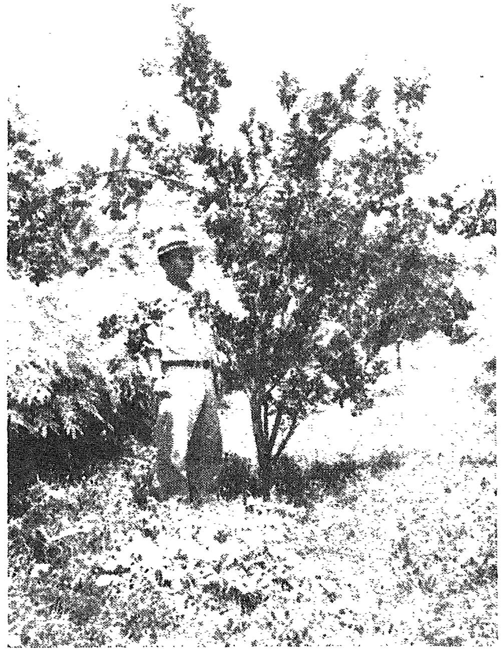

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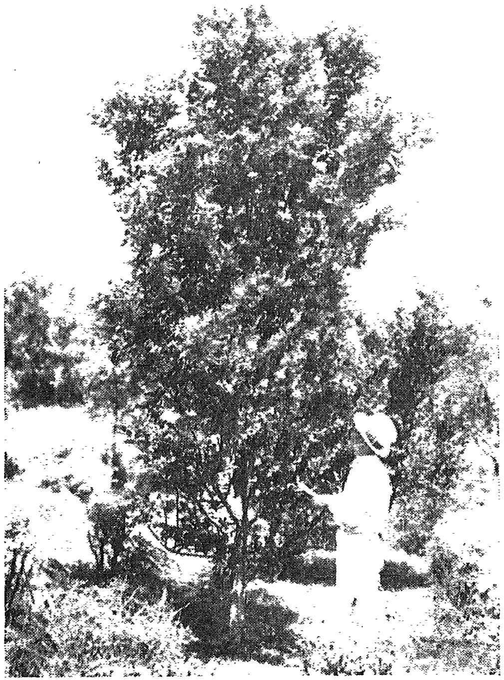
PLATE 6.



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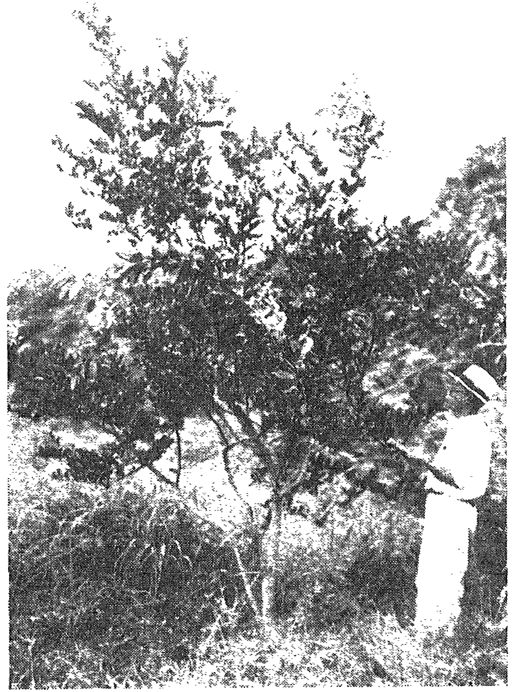

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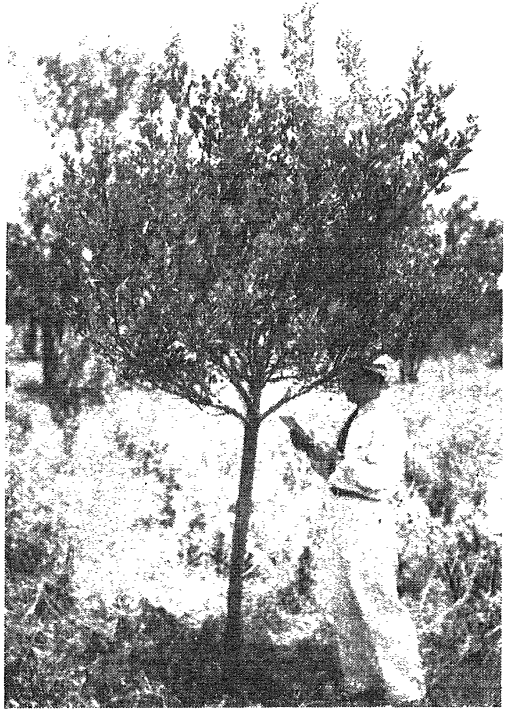

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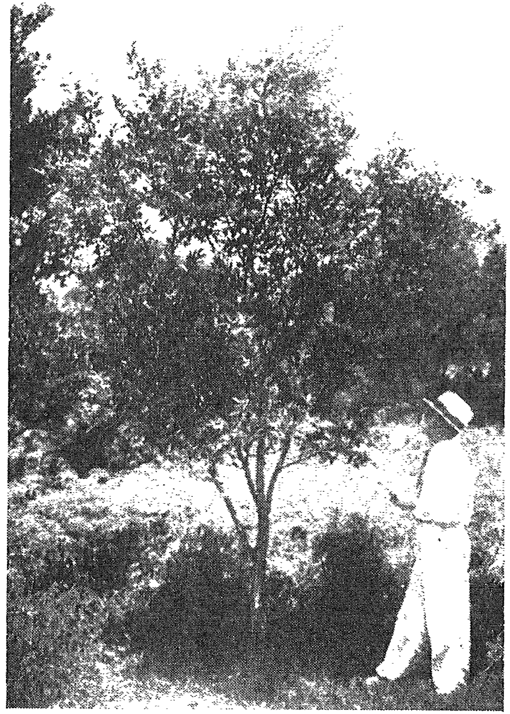

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PLATE 8.

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PLATE 9.

A COMPREHENSIVE STUDY ON SYMPTOMS OF ABACÁ MOSAIC [1]

By Melanio R. Calinisan
Of the Bureau of Plant Industry

NINE PLATES

The present paper deals with a study on symptoms of abacá mosaic. This work was started in March, 1938, with the end in view of bringing to light a vivid picture of a mosaic-infected abacá plant. And also, to make the abacá farmers familiar with the disease. Since abacá mosaic was first reported by the writer(1) in 1934, nobody as yet has given a full description of the symptoms of the disease. Recently, however, Ocfemia and Celino(5) described the symptoms of mosaic on abacá plants but the description was only confined to seedlings which they used in their aphid-transmission experiment.

Although the importance of this work was only recently realized, constant observation by the writer and contact with diseased plants for the last six years, afforded at least, sufficient background in taking notice of the different variations in symptoms as they actually occur in the field. At this juncture, it is not amiss to state that the symptoms which are being described and discussed to a greater extent hereunder have given additional information and more comprehensive description (than the writer's(1) previous and earlier observations) on the disease. It is, therefore, hoped that the presentation of this paper would serve further than merely elucidating the previous work and observations of the writer.

This investigation was made in Davao, supplemented by periodical observations in the Plant Pathology greenhouse of the Bureau of Plant Industry at Manila.

GENERAL CONSIDERATION ON SYMPTOMS

The general characteristic features of a mosaic-infected abacá plant are singularly distinct from those manifested by other abacá diseases. For this simple reason it can be identified correctly without confusion. Anyone with a normal vision and well acquainted with the disease can readily recognize a seriously

[1] Read before the Fifth Philippine Science Convention held on February 22, 1939.

infected plant at a distance of from 10 to 30 feet by merely looking at the leaves. The disease possesses all the characteristic aspects of mottling due to mosaic while a normal leaf is apparently green with a more or less uniform distribution of the chlorophyll.

The abacá plants are attacked by mosaic in all stages of its growth, that is, from the time the plant emerges from the ground up to maturity. It is not unusual to find diseased mother plants produce or bring forth mosaic-infected daughter plants. Also, abacá rootstocks or suckers from mosaic-infected mother plant or stools, when planted, almost invariably produce mosaiced abacá. Having in mind the systemic nature of the disease and the relationship between the daughter and parent plants, the writer has adopted the term *intrinsic* infection for any infection that may have been acquired by the daughter plants direct from the diseased mother plants. On the other hand, for any infection which may have come from extraneous sources—perhaps through the agency of certain insect vectors(2), (5)—the term *extrinsic* infection was designated. Magee as mentioned by Wardlaw(6) called it *primary* and *secondary* to indicate respectively these two forms of infection on banana by bunchy-top in Australia.

Not all plants in a mosaic-infected stool may show the symptoms of the disease. Sometimes only one, two or three diseased plants may be found infected in a stool of 25 to 30 plants. In severe cases, however, all plants in a hill, regardless of its size, may be infected with mosaic. Those seemingly healthy plants in a partly diseased stool are found not advisable to use as planting materials. The risk lies in the fact that since the disease is systemic in nature, the virus might be present, but sufficient time has not yet elapsed before the symptoms appear. Or, it might be that, externally, the plant appears healthy but the symptoms are masked or still obscure to render them visible to the naked eye. When such materials are planted the mosaic disease is likely to be carried over to new plantings.

Where bunchy-top is also prevalent in a mosaic-infected locality the two diseases may occur simultaneously on the same plant. Under this condition both the bunchy-top and the mosaic symptoms are manifested in one individual plant. The necessity of proving further the existence of these two diseases on one plant in future experiments is, therefore, in order. It was noted(3) that in a field where both mosaic and vascular wilt disease ex-

isted, these two diseases were found attacking the same plant. However, no case has as yet been found wherein a combined attack of the three diseases, namely, the mosaic, the bunchy-top and the vascular wilt occurs in one plant.

In 1931, the writer observed that in some plantations in Davao, wild canna, *Canna indica* Linn. was infected with mosaic. It was found side by side with or in close proximity to the mosaiced abacá as shown in Plate 9. The symptoms on the canna and on the abacá were similar in appearance (Plate 9).

Under the conditions obtaining in Davao the extent of mosaic infection varies from slight to severe in certain individual fields. At present the seat of serious infection is found in Lasang, Davao. Although the foci of infection are dissipated here and there all over the entire abacá–growing localities in Davao and partly in Cotabato, it appears that the disease, in low places, is more serious now than uphill. In certain low places, the disease has so spread as to constitute an epidemic causing the abandonment of some plantations. Actual count of healthy and mosaic-infected stools belonging to Southern Davao Development Company, Lasang, Davao has demonstrated that in a plantation 6 to 8 months old, the infection was 59.41 per cent. Where the plantation was 2 to 3 years old, the infection was 60.22 per cent; 7 to 8 years old, 62.45 per cent.

So far, no cases of recovery have been observed among diseased plants both in the field and in the greenhouse. Diseased plants, especially those infected intrinsically may die a premature death while other plants, however, may continue to grow until the fruiting stage is reached. In cases like this, the symptom of mosaic disease is traceable to the flowers (Plates 5 and 6) and fruits (Plate 7). Of the 2,775 abacá seeds from diseased fruits that were planted in closed cages, 880 seedlings germinated but not a single plant showed symptoms of mosaic after a period of 8 months. Based upon this result, the probability is, that the abacá mosaic virus is not carried over through the seeds.

Diseased stalks when already mature are also strippable like the normal ones but as to whether or not the productivity of the plant and the tensile strength of the fibers are affected remain to be investigated. It might be of interest to note that the three varieties of abacá grown commercially in Davao, namely, Tañgo-ñgon, Maguindanao, and Boñgolanon, are all subject to mosaic infection.

Based on the foregoing discussion and the writer's previous observation in 1934(1) it is believed that the mosaic disease of abacá in the Philippines is similar to, if not closely identical with, the new virus disease of banana reported by Magee(4) in Australia.

SYMPTOMS

On the foliage.—The first external indication of mosaic infection is the appearance of spindle-shaped patterns on the nether surface of the leaf running in the same direction as the veins (Plate 1, fig. 1, left side of the leaf). This characteristic incipient symptom may be noted simultaneously with the clearing of the veins in between them as shown on the right side of the leaf (Plate 1, figs. 1 and 2). The spindle-shaped pattern varies in size, ranging from 20–30 millimeters long by 2–3 millimeters wide. This consists of light chlorotic linear areas forming irregular and broken stripes from the midrib to the leaf margin. Sometimes anastomosing of the spindle-shaped pattern may take place (Plate 1, fig. 1). On the center of the spindle-shaped pattern may occasionally appear a sort of a green dot or speck simulating an "island." Toward the long axis of this "island" may radiate a short fine line of green color with one end pointing to the midrib, the other running toward the leaf margin. Sometimes this green speck or "island" assumes also the shape of a spindle (Plate 1, fig. 1, left side of the leaf). In the early stages of the disease, the spindle-like streak is found in localized portions of the leaf area. Two or more of them may coalesce or fuse laterally, or may join together end to end to form larger or longer composite chlorotic areas as the case may be (Plate 1, fig. 1, left side of the leaf). The color may also vary. Ordinarily the spindle-like streak appears yellowish pale green although at times it may have rusty appearance. The rusty color may be noted on the blade, midrib, and petiole of the leaf.

On the unfurled leaves the mosaic patterns are oftentimes decidedly delineated—the pale yellowish green contrasting sharply with the normal green. On the youngest folded leaf the characteristic symptom of mosaic infection is the presence of ring-like bands of yellowish streaks alternating with wider normal green stripes. Sometimes these ring-like streaks consist of fine threads of vivid green alternating with wider bands of light yellow color.

Cases have been observed where the mosaic-infected leaf was followed by an apparently healthy leaf. Under this condition, it is believed that the symptoms might have been masked with

something not yet well understood. Later on, however, the symptoms may reappear on the succeeding leaves. It was further observed that in some occasional instances the subsequent leaf that followed the first infected one showed less distinct mottling. Ordinarily, however, the opposite is true, that is, the leaf that follows the infected ones is severely chlorotic and disfigured by a more pronounced mottling.

Infected leaves are sometimes corrugated to form irregular depressions. No case has as yet been observed either in the field or in the greenhouse where infection works backward, that is, the old normal leaves produced prior to the manifestation of mosaic symptoms remain normal green. This is due perhaps to the cessation of growth on the older leaves.

On the midrib and petioles of the leaf.—Cases have been observed where the first sign of mosaic infection appeared on the midrib while the leaf blade was apparently normal. The presence of light yellow or orange streaks on the midrib is indicative of mosaic infection. The subsequent leaf may show more distinct and elongated yellowish streaks both on the petioles and midrib although no mottling on the leaves may be traced. The next ensuing leaf may show the characteristic mottling of the petioles, midrib and leaf blade. It was observed in most cases that when the petioles of the infected leaf appeared salmon or somewhat rusty in color, the inner tissues usually became discolored or necrotic. In a more advanced stage of the disease gradual blackening and dying of the tissues also took place.

The streaks on the midrib and petioles vary in size and shape (Plate 2, figs. 1 and 2, and Plate 3). They appear dark green with yellowish background as shown distinctly in Plate 3. The long axis of the dark green streak runs from the base of the petiole towards the tip of the midrib.

On the stalk or pseudostem.—The symptoms on the stalk or pseudostem of a diseased abacá are oftentimes hard to find especially when the plant has attained maturity probably because of the dominating natural dark brown to purple color of the outer and most exposed portion of the stalk. However, as the outermost leaf sheath is removed to expose the next layer, which is usually lighter in color, the mosaic symptom, if there is any, becomes seemingly evident (Plate 4). It is characterized by the presence of spindle-like streaks running longitudinally toward the long axis of the pseudostem (Plate 4). Again, the mottles vary in shape, size and color. The color ranges from yellowish white to purplish streaks. In some cases, a small dot

or elongated "island" may be seen on the center of the spindle-like pattern (Plate 4). Similar to the mode of mottling on the leaves, two or more streaks on the stem may coalesce laterally or fuse on either ends to form larger or longer streaks as the case may be. In a certain case examined, mottling on the stalk is apparent up to the fourth inner leaf sheaths. On young plants the natural color of the stalk is usually green so that the patch-like mottling becomes readily discernible (Plate 3).

Symptoms on the inflorescence or "heart."—Healthy mother plants produced healthy inflorescences or "hearts." On the other hand, mosaic-infected plants invariably produced diseased flowers. This was observed in a badly infected plantation in Lasang, Davao. It was noted that a newly emerged inflorescence of a mosaic-infected abacá plant might show the characteristic symptoms of mosaic disease (Plate 5). The mottling condition appears very distinctly on the outside part of the bracts rather than on the inside. It is due perhaps to the subdued color of the latter. Mosaic-infected "heart" manifests the presence of yellowish light green streaks radiating from the base to the tip of the bracts (Plate 5). As shown in Plate 5, the light color represents yellowish light green streaks, the darker manifests the natural reddish coloration of the bract.

The male flowers are shown in Plate 6, figs. 1, 2, and 3. The characteristic appearance of mosaic disease on the inflorescence simulates that which is found on the pseudostem. The presence of spindle-shaped streak is very evident (Plate 6, figs. 1 and 3). It radiates from the base towards the tip of each bract. Two or more of those spindle-shaped streaks may coalesce along the sides or at either ends to form a larger or longer mottling as shown in Plate 6, figs. 1 and 3. The mottling becomes apparent up to the innermost bract of the infected flower. On the other hand a normal inflorescence (Plate 6, fig. 2) does not exhibit any mottling on its bracts. When the infected bracts are removed one after the other they leave distinctly discolored scars on the rachis (Plate 6, fig. 3). On the other hand the scar left by the healthy bract is perfectly white and healthy (Plate 6, fig. 2). A cross-section of a mosaic-infected rachis showed distinct brownish discoloration on the epidermal tissues and also in some portions of the endodermis.

Symptoms on the fruits.—Diseased fruits show also the characteristic mottling but it is not readily discernible at long range. It constitutes violet wedge-shaped streaks and may be seen on four sides of the finger (Plate 7, fig. 1).

The fingers in a diseased hand do not all exhibit decided mottling. Some may exhibit more distinctly than the others. On the other hand, a normal finger never shows any mottling as shown in Plate 7, fig. 2. The green color of the skin is more or less uniform. When the mosaic infected fruit is cut open the inner tissues appear brown while those in a normal finger are perfectly white and healthy. The brownish coloration is usually found on the epidermal cells. In some cases, although not too often, sterility and decaying of mosaiced fruits were noted (Plate 7, fig. 1).

The characteristic mottling on the foliage, midribs, petioles pseudostems, inflorescences, and fruits; the transmission of the disease systemically to new plantings either through mosaic-infected sucker or suckers from diseased stools; and the inability of diseased plants to recover once they become infected are very strong presumptive indications, that the disease may be classified under the group of infectious chlorosis.

SUMMARY

The present paper is an exhaustive study on symptoms of mosaic disease of abaca in Davao. Symptoms of the disease on the leaves, midribs, petioles, pseudostem, inflorescence, and fruits are described.

ACKNOWLEDGMENT

The writer is profoundly grateful to Dr. Feliciano M. Clara, Chief of the Plant Pathology Section for valuable criticisms offered during the progress of this work and to Mr. Crispiniano C. Hernandez, Junior Plant Sanitation Inspector in charge of the Plant Quarantine Service in Davao for furnishing the necessary plant materials for the investigation.

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ILLUSTRATIONS

PLATE 1

[Photographed by the Photographic Division, Bureau of Science, Manila]

FIG. 1. A portion of the first infected leaf of abacá plant showing the characteristic incipient symptom of mosaic disease. Note the spindle-shaped pattern on the left side of the leaf running almost parallel to the veins. Note also the clearing of the veins on the right side of the leaf blade.

2. A portion of the second subsequent infected leaf of the same abacá plant shown in Fig. 1. Note the more advanced symptom of the disease. Examine very carefully the mottling appearance of this second leaf and compare it with the first. The lighter color is yellowish pale green and the darker, normal green. Note also that the clearing of the veins on the right side of the leaf (Fig. 2) is more distinct than that in Fig. 1.

PLATE 2

[Photographed by the Photographic Division, Bureau of Science, Manila]

FIG. 1. Upper surface of the abacá leaf infected with mosaic disease. Note the characteristic mottling of the leaf blade and the midrib and compare it with that in Fig. 2.

2. Lower surface of the same leaf shown in Fig. 1. Note the characteristic mottling of the leaf blade and the midrib and compare it with that in Fig. 1.

PLATE 3

[Photographed March, 1938, Davao City]

Upper portion of the pseudostem of a mosaic-infected abacá plant showing the various shapes of patch-like shades which are the characteristic symptoms of mosaic disease.

PLATE 4

[Photographed March, 1938, Davao City]

A portion of a mature pseudostem showing the symptoms of mosaic disease. Note the characteristic spindle-shaped marks or mottled areas running toward the long axis of the pseudostem.

PLATE 5

[Photographed March, 1938, Davao City]

A newly emerged inflorescence or "heart" of a mosaic-infected abacá plant showing the symptoms of mosaic disease. Note the characteristic mottled appearance as shown clearly on bracts 1, 2, and 3.

PLATE 6

[Photographed April, 1938, Davao City]

FIG. 1. Male inflorescence or "heart" of abacá plant infected with mosaic disease. Note the spindle-shaped mottling on the bracts and compare it with Fig. 2.

2. A healthy male inflorescence or "heart." Note the absence of mottling on the bract and compare it with Figs. 1 and 3.

3. Mosaic-infected male inflorescence or "heart" of abacá plant with a portion of the rachis. Note that the bract scars as indicated by the arrow on the rachis show also symptoms of mosaic disease. The bracts are also badly mottled.

PLATE 7

[Photographed April, 1938, Davao City]

FIG. 1. Young green fruits of abacá plant infected with mosaic disease. The whole bunch is called a "hand" and one fruit is called a "finger." Note the spindle-shaped mottling on the "fingers." Note also the discoloration at the point of attachment of the hand to the rachis and compare it with Fig. 2.

2. A healthy bunch of abacá fruits or "hand" from a healthy abacá plant. Note the absence of mottling on the "fingers" and compare it with Fig. 1.

PLATE 8

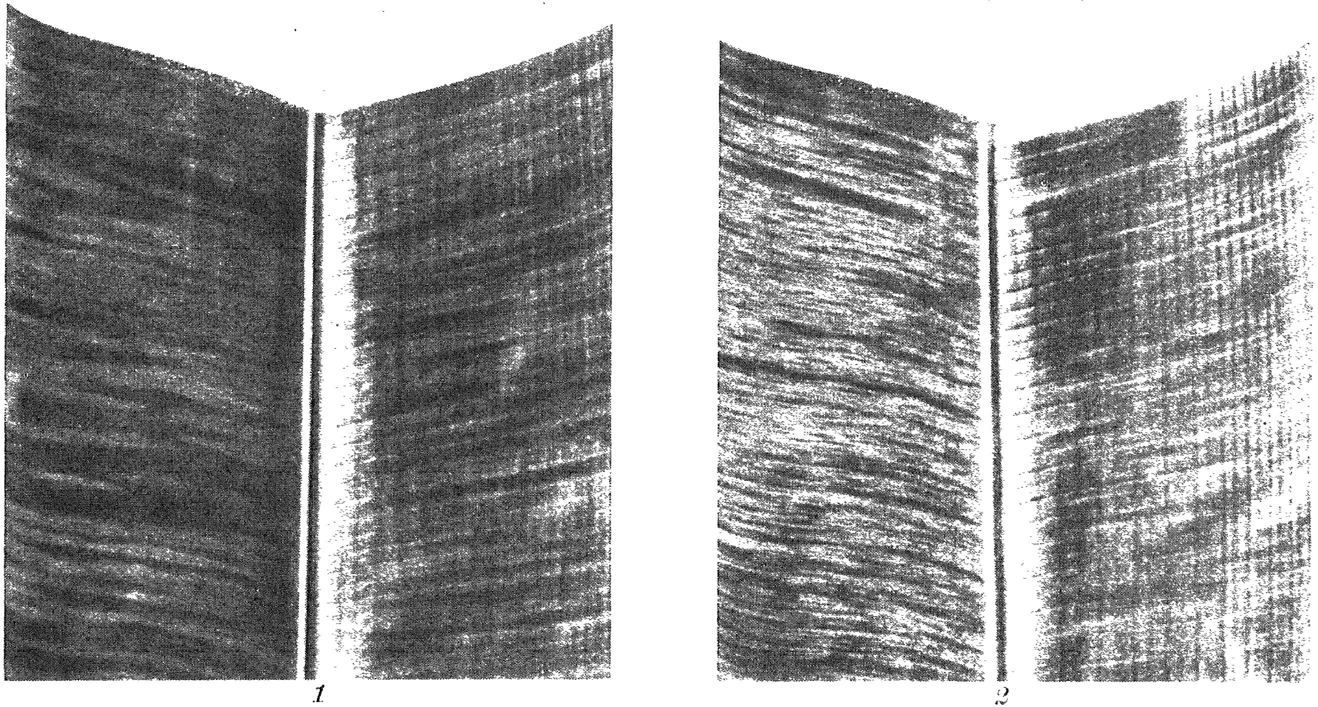
[Photographed April, 1938, Davao City]

Abacá suckers showing the after-effects of early mosaic infection. Note the partial deformities and stunted growth of the plant. Note also the fan-like appearance of the leaf sheath.

PLATE 9

[Photographed by courtesy of Mr. Kojima of Ohta Development Co., Davao]

Cannas, *Canna indica* Linn. infected with mosaic disease. Note a hill of abacá in the background which is also infected with mosaic.



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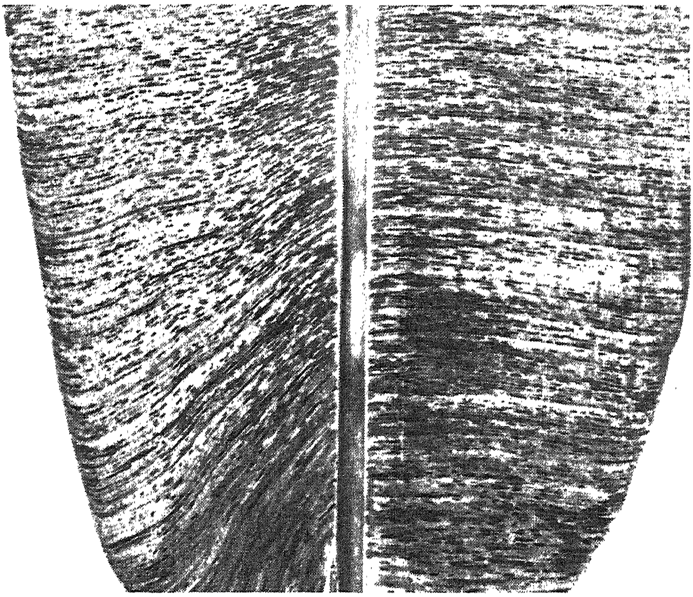

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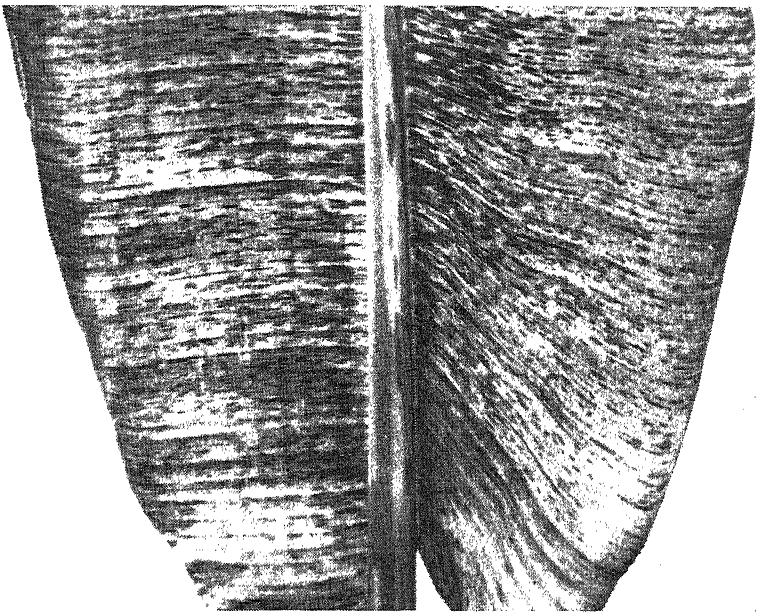

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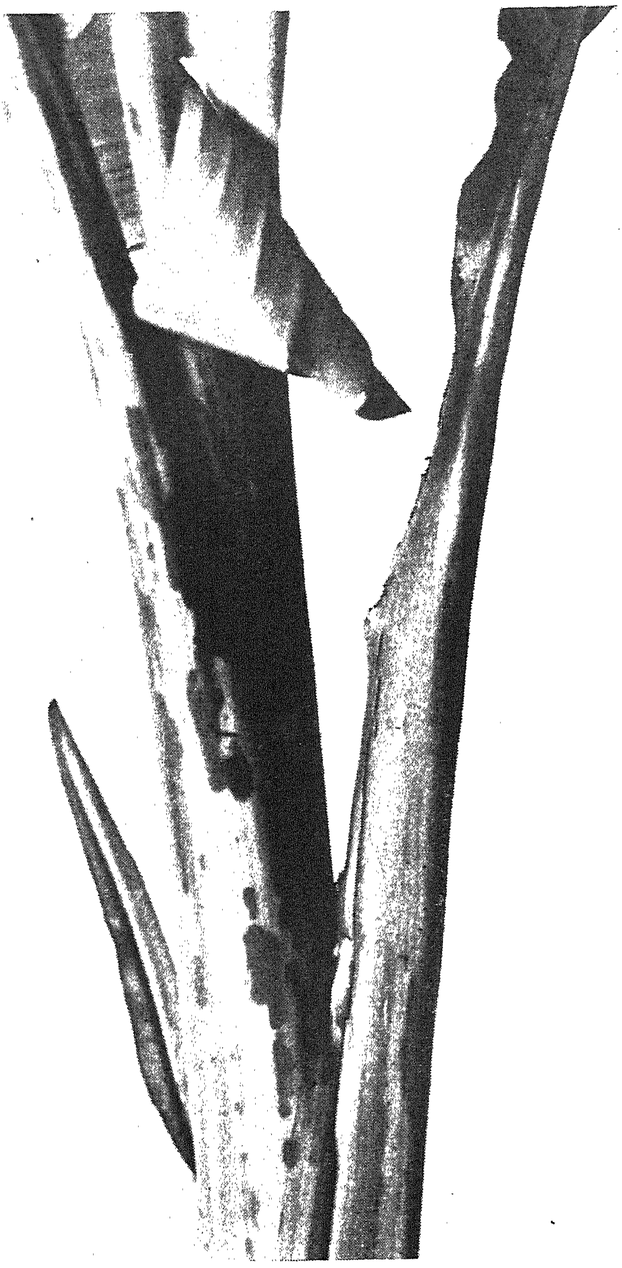

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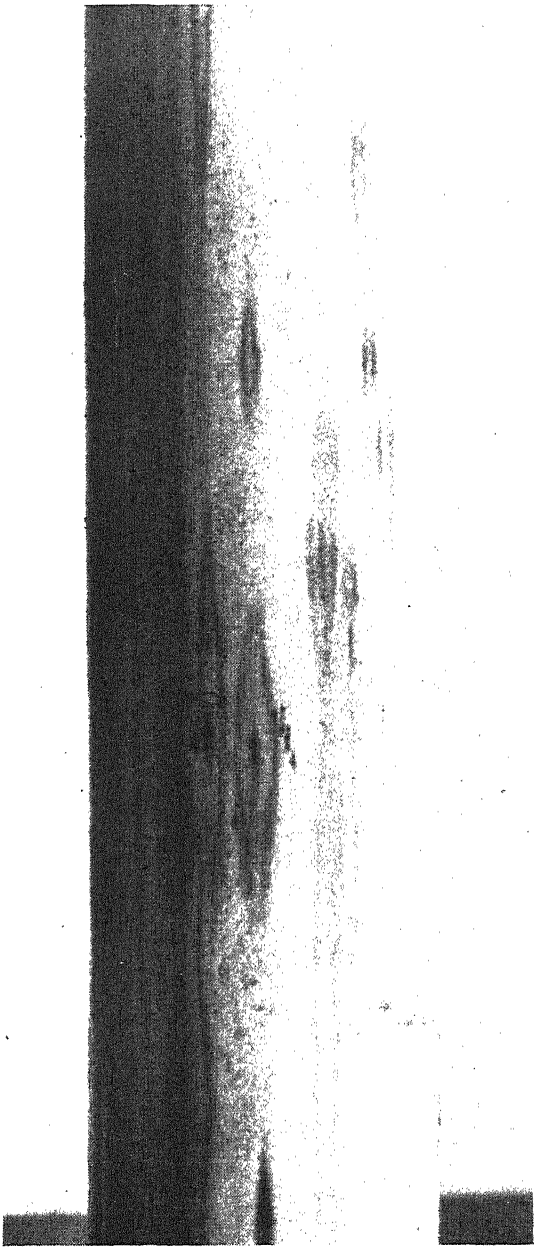

PLATE 4.

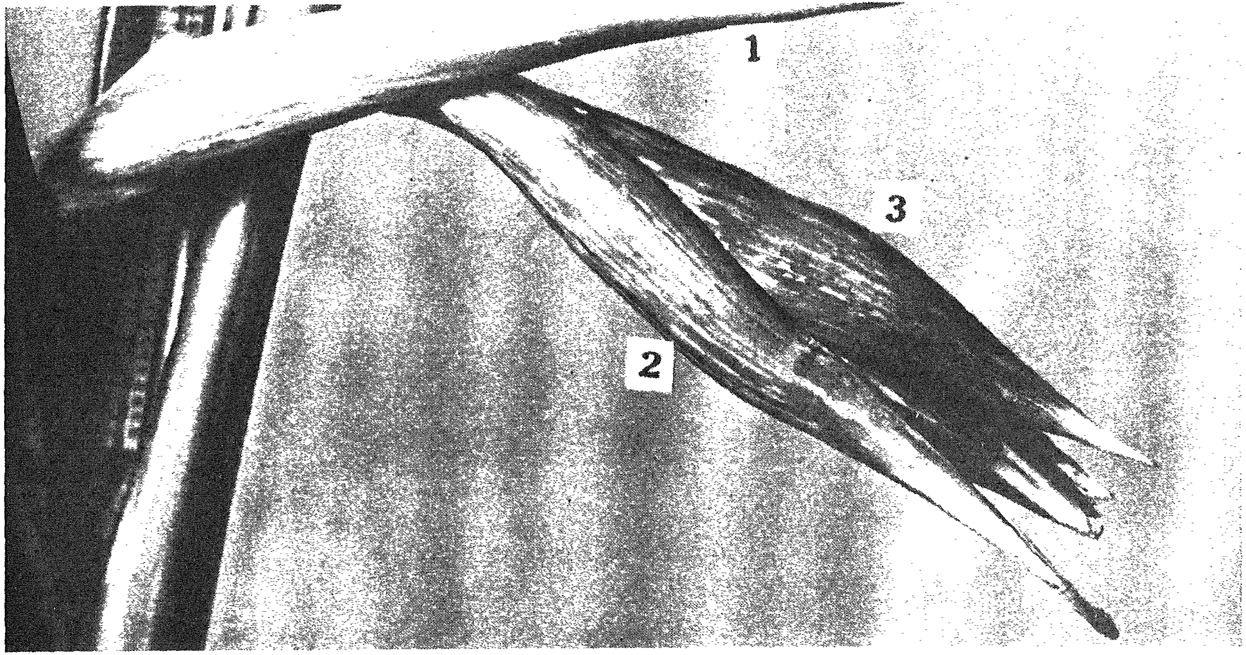

PLATE 5.

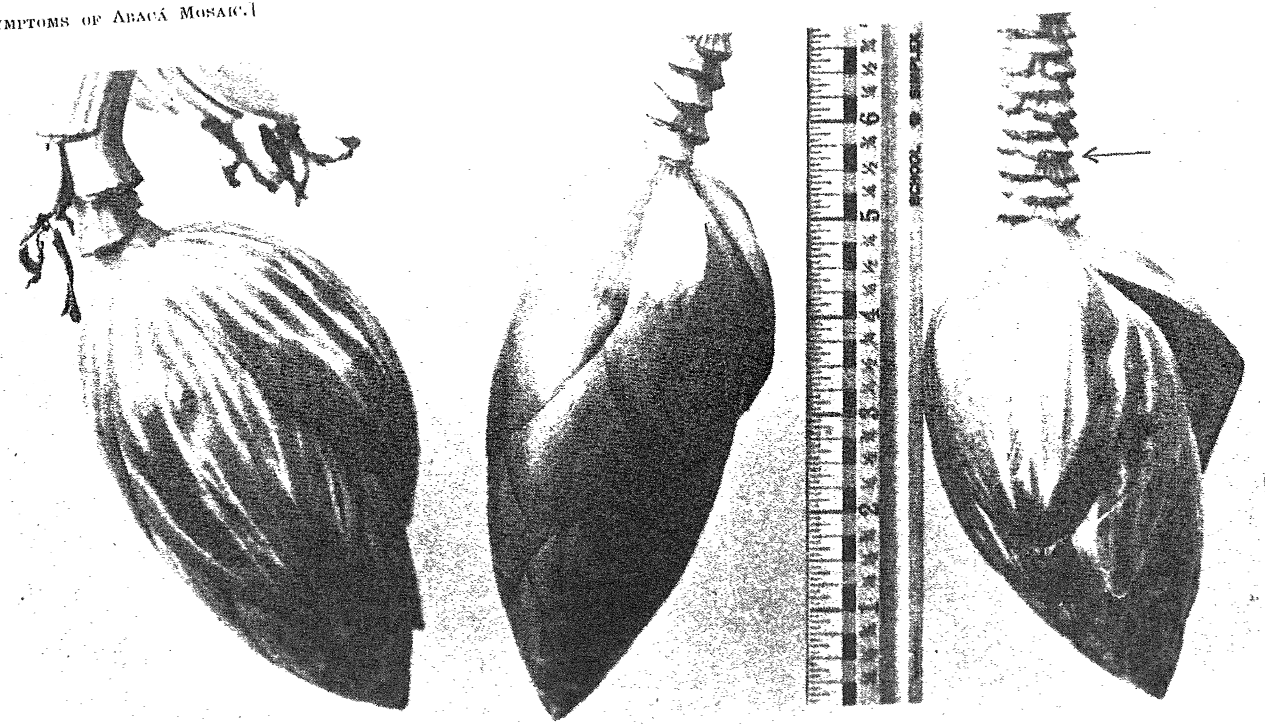

PLATE 6.

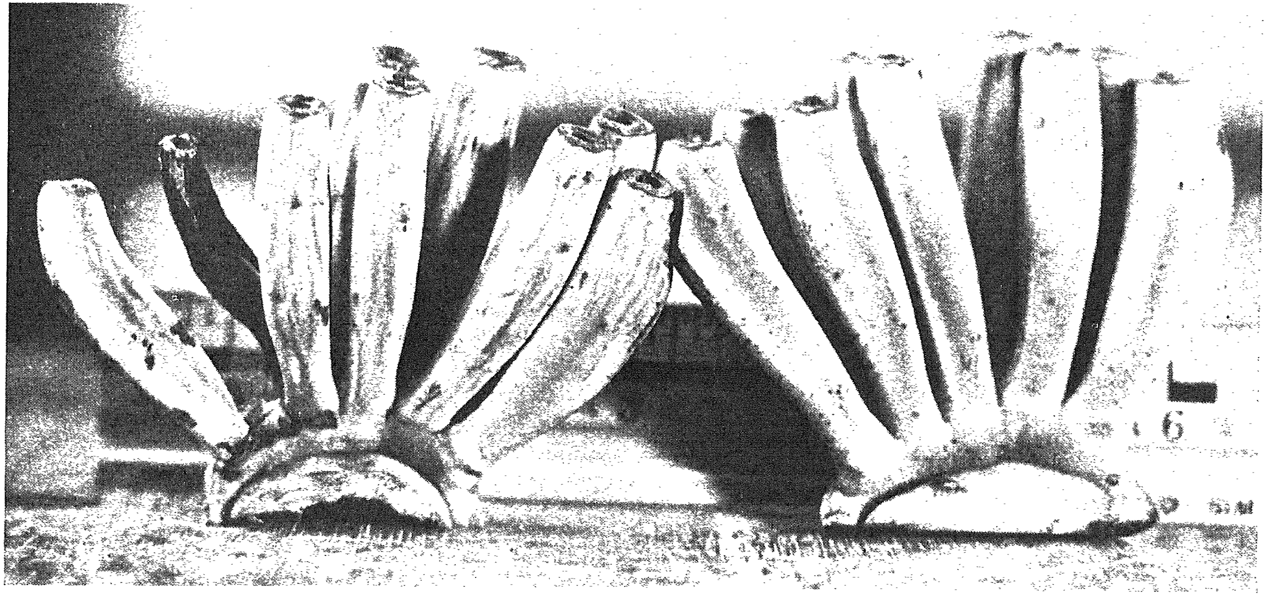

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PLATE 7.

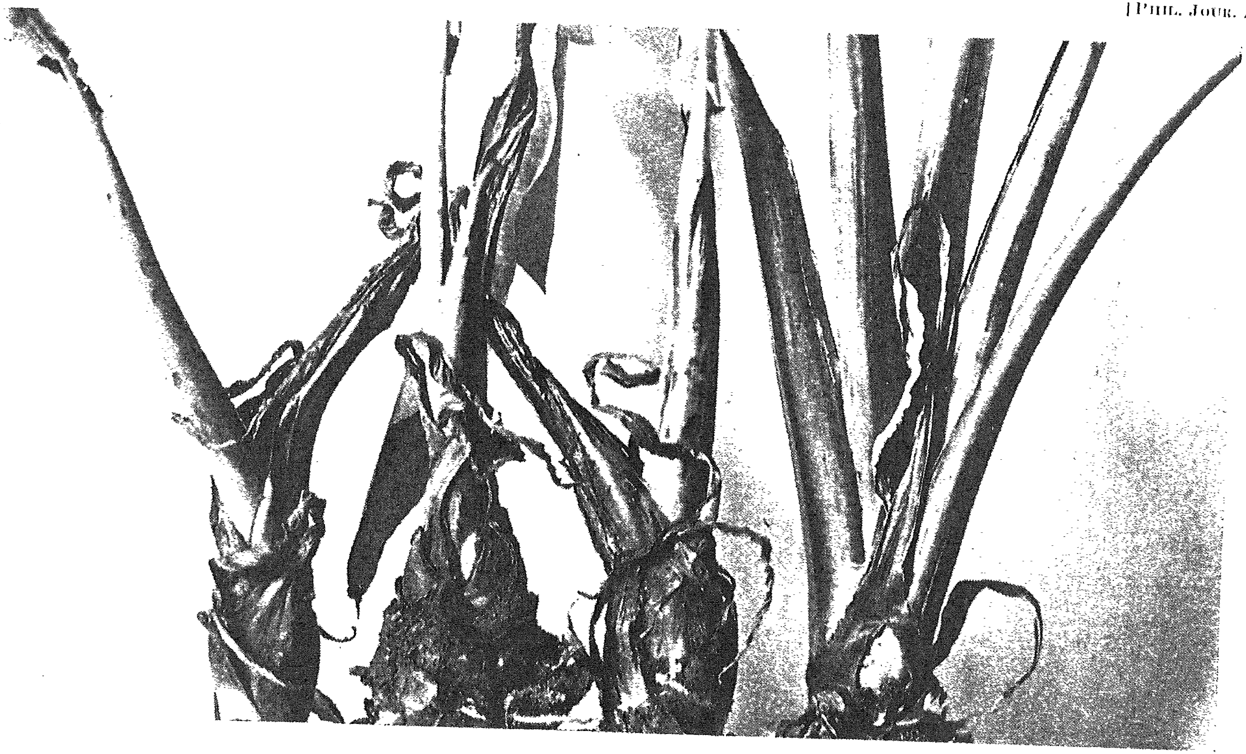

PLATE 8.

PLATE 9.

NOTES ON BUD DIFFERENTIATION IN CARABAO MANGO (*MANGIFERA INDICA* L.)[1]

By Epitacio A. Lanuza

Of the Horticulture Section, Bureau of Plant Industry

SEVEN PLATES

The present article consists of a study on bud differentiation in carabao mango before and during the flowering season, from February, 1937 to January, 1938. It, however, includes some previous observations made by J. A. Agati and E. O. Olivares during the mango seasons of 1933–1936.

Originally this work was conceived by Dr. M. L. Roxas, then Director of the Bureau of Plant Industry and by F. G. Galang, at present Chief of the Horticulture Section of the same Bureau and was intended as a "charter" in a series of studies on bud differentiation in all mango varieties in the Philippines, and eventually other fruit trees. In 1935, or just after the work[2] was well under way an article on the same subject by Alcala and San Pedro (1) of the College of Agriculture, University of the Philippines, appeared in the *Philippine Agriculturist*. While the article referred to may be of great interest to scientists it did not, however, treat of the practical phases involved in bud differentation which may be of value to mango growers. This paper aims, therefore, not only to confirm conclusions drawn by previous investigators but also to throw more light on certain points still remaining obscure which may lead to direct application in horticultural practice.

REVIEW OF LITERATURE

It has already been known that fruit bud formation, on which fruit production depends, is influenced by a number of orchard practices such as cultivation, irrigation, pruning, smudging, etc. Furthermore, it has been found by Bradford (4) that fruit buds are formed in the summer previous to their blossoming. It was

[1] Prepared with the advice of Mr. F. G. Galang, Chief, Horticulture Section, Bureau of Plant Industry.

[2] Mr. J. A. Agati and Mrs. E. O. Olivares made observations both in Novaliches, Rizal and in Central Experiment Station, Singalong, Manila.

Goff,(10) (11) however, who first recognized definitely the initial stage of flower bud formation in deciduous orchards.

In the Philippines a method called smudging has been evolved to induce mangoes to flower. Just when mango smudging was first practiced in the Islands cannot be ascertained. Suffice it to say that the practice has been resorted to since time immemorial in some provinces of the Islands, particularly Bataan, Bulacan, Cavite, Pampanga, and Rizal. The first record on the subject is by Wester(19) followed by Galang(7) Gonzales(13) and Galang and Agati(8) (9) in the order given.

Although already an established fact that mango buds are easily activated in producing flowers by smudging, there are cases observed by the writer as well as by other workers as Alcala and San Pedro(1) and Galang and Agati(9) whereby activated buds turn out foliar instead of floral flushes.

Smudging, although apparently effective in inducing flowering, is not only laborious but also expensive. In spite of such costly operation and hazards, however, some farmers at times continuously smudge their trees even for over a month not only because of ignorance of the proper stage for smudging but also because of fear of reversion.

A belief common to a number of mango owners is that leafy shoots develop instead of flower shoots if smudging is stopped before the inflorescence becomes clear to the naked eye. Alcala and San Pedro(1) doubt such an occurrence as long as buds have already differentiated. Goff(10) believes that there is little reason to suppose that there could be reversion of flower buds. He says that the failure of apple and pear orchards to bloom is not due to reversion but most probably to failure in forming flower buds.

In passing it may be mentioned that another belief entertained by a few farmers is that there are certain pre-flowering characteristics prior to flower formation. Although such a behavior has been ascertained in some kinds of fruit trees, it has not been recorded or established in mangoes. Drinkard(6) for instance reports that the first corrugation on the crown (of buds) of Olderberg apple indicates floral formation. In Ball's(2) treatise on the time of differentiation and the subsequent development of the blossom bud of plum, he quoted Dr. Beale as follows: "Before December, by the bluntness of the bud you may discover what branch will bear fruit the next season immediately after flowering." A casual observation made by the

writer on avocado trees at La Granja while assistant superintendent of the Granja Sugar Cane Experiment Station at La Carlota, Occidental Negros, was that some avocado trees exhibited greater waviness of mature or maturing leaves prior to flowering.

OBJECTIVES OF THE STUDY

The objects of the present study are:

1. To note the external signs as well as the development of leaf buds and flower buds.

2. To determine the internal changes taking place in flower buds and leaf buds and their differences both for smudged and non-smudged trees.

3. To establish such differences so as to reduce, if not altogether avoid, the excessive cost of smudging of some carabao mango trees.

4. Incidentally, to blaze the way for studies on the same or related subjects in some other fruit trees in the Philippines with the object in view of throwing light on proper cultural practices.

MATERIALS AND METHODS

The work was conducted both at the then Singalong Central (now Central Experiment) Station, Manila and Lamao Horticultural Station, Limay, Bataan, of the Bureau of Plant Industry, as well as in Novaliches Mango Orchard, Rizal, on smudged and non-smudged carabao mango trees about 15 years old or more. Prior to this study, these trees had been in bearing for sometime. It might be mentioned in passing that the trees at Novaliches had been pruned and sprayed, some days before smudging, to protect the shoots from the attack of twig borers.

The preliminary field studies were started by Mrs. E. O. Olivares in October, 1933. With the transfer of Mrs. Olivares from the Horticulture Section to the Plant Breeding Section, the work was temporarily stopped. Sometime later, the task was entrusted to the writer, who conducted a systematic study on the subject, employing some of the results already gathered.

It is to be expected that since this was the first work of its kind in the Bureau, many drawbacks and obstacles were encountered at first, such as difficulties due to the presence of hairs in the buds, latex, etc.

Ten trees were selected at Novaliches, Rizal; four at Singalong Central (now Central Experiment) Station in 1937 (5 in 1934); and six at Lamao Horticultural Station.

On each tree a number of buds were marked in October or sometime before flowering. This was done by putting rings with the use of white lead paint on the twigs bearing the buds for study. Young twigs (with tender leaves) were marked with two rings, mature ones with one ring. This was done in order to observe how long differentiations in different stages of bud formation would occur.

Biweekly collections of 3 to 6 buds made every time from each tree were put immediately in fixatives[1] consisting of fifty-fifty 50 per cent alcohol and commercial glycerine, and then brought to the Central Office laboratory for detailed macroscopic and microscopic observations.

The first stage and the complete differentiations were determined microscopically while the appearance of flower formation was gauged with the "naked eye."

For organographic studies, cross-sections of buds and dissections of the parts were made. For the detailed microscopic studies, median longitudinal sections were availed of. In making the latter sections two methods were followed: (1) "Free" sectioning (without embedding) by means of a sliding microtome. For rough examinations, sometimes good sections were also obtained with the use of gillete blades. (2) With the use of rotary microtome after embedding the materials in the usual paraffin method as outlined by Chamberlain.(5) While for detailed studies good sections were obtained from those embedded, for histological relations of parts some fairly good sections were also obtained in the free sectioning which were helpful in finding the arrangement of the different parts. Sometimes sections taken after embedding had slight alterations in the arrangements of the tips of both the scales and leaf primordia.

For those used in median sectioning, slabs were taken from opposite sides leaving convenient median sections about 1 mm. to 1.5 mm. thick before they were placed in the killing and fixing reagent and kept therein for a day or two after which they were washed off for embedding.

Materials for embedding, after washing with running water for about 24 hours, were treated in accordance with the method of Chamberlain.(5) Sectionings were made to a thickness of 8 to 10 micra.

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[1] The writer used the following fixative for some specimens especially for dissections: Alcohol (70 per cent) 90 cc.; formalin, C. P. (35 per cent) 6 cc.

The paraffin method offered certain difficulties possibly on account of the hairs on scales and foliar primordia that caused some breakage to the sections. Similar difficulties were experienced by Tufts and Morrow(17) with apple and pear. However, a number of fairly good sections were obtainable for purposes of this study.

Observations were also concomitantly carried out on the trees for pre-flowering characteristics that could be easily distinguishable to the naked eye. For this purpose twigs of the early stages as those in Novaliches (described below) were selected to start with.

BRIEF DESCRIPTIONS OF TWIGS BEARING BUDS AT NOVALICHES, RIZAL, DURING THE PERIOD OF SELECTION OF BUDS FOR USE IN THE STUDY.

Tree I.—Shoots appeared on October 5 but on November 10 they were still tender although the leaves were fully developed. Leaves were light green.

Tree II.—Shoots appeared on October 31 with lengths ranging from 15 to 20 cm. at the time of observation. The leaves were fully developed on November 10 although still tender.

Tree III.—Shoots appeared in October but on November 10 they were still tender. The leaves were fully developed but younger in appearance than those of Tree I. They were light purple.

Tree IV.—Shoots appeared on October 31, of 15 to 20 cm. in length at the time of observation. The leaves ranged from 13 to 15 cm. and were light purple like those of Tree III.

Tree V.—Shoots appeared on October 12; length from 18 to 30 cm.

Tree VI.—Shoots appeared on November 1. On the 10th they were from 15 to 20 cm. long with tender and immature leaves ranging from 7 to 15 cm. each.

Tree VII.—Shoots appeared on October 10 but were almost similar to those of Tree I. On November 10, the shoots were from 18 to 30 cm.

Tree VIII.—On November 9 the shoots were from 14 to 20 cm. in length with 7 to 15 leaves each.

Tree IX.—Shoots appeared on November 3–10. At the beginning of observation, they were still tender with undeveloped leaves, the length ranging from 7 to 10 cm.

Tree X.—On November 9 the shoots were from 14 to 20 cm. in length and had 7 to 15 leaves each.

The different trees as noted above had been briefly described to show the relative stages or ages of the buds at the beginning of the observations.

OBSERVATIONS

The terminal or apical bud in its dormant stage is more or less conically-shaped with either blunt or pointed tips set squarely just above the well-developed leaves of the last flush (Plate 1, fig. 1). Note its organography (Plate 2, fig. 1): S, scale; TS, transition scales; F, foliar primordium; am, apical meristem. Its color (following the terminology in Color Standards and Color Nomenclature by Robert Ridgway) may either be lumiere green with antique brass; light apple green with tips of olive brown, blackish brown, light cacao brown, blackish, sooty, or light brown; spinach green with tips of antique brown, brown, and benzo brown; apple green or dark green with tips of different shade of colors; etc. When they become old, however, the buds turn light brown or blackish brown.

The buds are covered with scales of almost similar form but of various sizes depending upon the girth of the twig on which they are borne, ranging from 2 to 9 mm. at its narrowest portion at the base and 4 to 14 mm. at the widest portion; and from 2 to 6 mm. long from the base of the outermost scale to the tip of the bud.

The scales converge on the top and show an appearance of compactness, clasping tightly the inner parts when buds are in dormancy (Plate 1, fig. 1).

Upon smudging or when further development or growth goes on, the scales most usually become somewhat loose at the tips (Plate 2, fig. 4). Still with further development the inner scales grow longer and slightly wider (Plate 3, figs. 2–16 and Plate 4, figs. 1–17a) at the same time that the scales are progressively shed off from out inward, due perhaps to the growth of the apical meristem as well as of flower cluster primordia from the axils of the inner scales.

In the study of bud differentiation axillary buds have to be considered. Therefore, in the present work they were concomitantly taken.

The structure and arrangement of the different organs of the axillary or regenerative buds (Plate 1, fig. 11) are similar to the terminal ones with the exception of the slightly compressed appearance of the bud and its parts (Plate 1, figs. 11, 15, 18), the outermost scales which are shaped like scales of fish (Plate 1,

figs. 13 and 14), and the lesser number for both the scales, transition scales, and foliage leaves.

Scales.—Microscopical examination shows the seeming simplicity of the vaginate appearance of the scales. The outermost ones are tough and hard with prominent protrusions that are either blunt or pointed with the dorsal scales conspicuously ridged (Plate 1, figs. 2 and 3). The inner ones have their exposed tips brownish or blackish, each one tightly clasping each other and protecting the meristematic tissues inside. Careful examination aided by a good hand lens shows traces of few hairs on these scales which are characteristic of foliage leaves. Every bud scale, at the early stage of development, terminates in an apical protuberance (Plate 1, fig. 1 and Plate 2, fig. 4), a structure corresponding and equivalent to the lamina of a normal leaf. These protuberances are not inhibited even at the advanced or older stage of the scales (Plate 3, figs. 2–16 and Plate 4, figs. 1–17a). This corroborates the findings of Alcala and San Pedro (1) on their work on Pico and Indian mangoes (the Carabao mango tree they worked on did not flower) wherein bud scales are of two distinct parts: (1) the broad sheath or sheath-like structure which forms the greater bulk of the scale, and (2) the laminar primordium which varies in form and size depending upon its position on the bud.

Sheath.—The sheaths on any one bud vary in size, thickness, and to a certain extent, in forms depending upon their relative positions (Plate 3, figs. 2–16; Plate 4, figs. 1–17a). The outer scales are thick, horny, and usually smaller than the few succeeding ones. They are usually triangular or ovate, brown, or blackish and sometimes greenish at the exposed parts and green to light green at the unexposed portion. The margins are thinner than the median portion. Such outer scales with the few inner ones immediately following have dorsal sides of the sheaths often ridged.

Careful examinations would show traces of some few trichomes or hairs on the sheaths that are of combined unicellular and multicellular types, usually of the latter one (Plate 1, figs. 10 and 12), and which are often destroyed or inhibited as the scales grow old or get exposed (Plate 1, fig. 2). The succeeding (inner) sheaths are of variable sizes.

Taken altogether, the scales (sheaths plus their protuberances or primordia) vary from 1.5 to 15 mm. for those of the terminal buds, and 1.2 to 12 mm. for the axillary buds depending upon the size and development of such buds.

Transition scales.—The transition scales usually range from one to three and sometimes more but not over six, depending upon the size and development of the bud. They vary in forms ranging from slightly ovate or ovate-cuspidate at the dormant stage (Plate 1, figs. 4–5 and 16–17) or narrowly cuspidate to thinly elliptic when further development goes on (Plate 3, figs. 14–16 and Plate 4, figs. 15a–17a). At first glance, due to curvature or slight folding of the sides near their tips, they sometimes appear slightly triangular. At the tips are protuberances (laminar primordia) while the ends of the sheaths at close examination are very slightly winged.

At full development the transition scales are decidedly narrow and elongated (Plate 3, figs. 14–16; Plate 4, figs. 15a–17a). A careful examination of these scales reveals some hairs at both margins and at times at the nether surfaces.

Transition scales (sometimes also called transition leaves) measure from 3.6 to 4 mm. long at dormancy and 10 to 20 mm. at full development, and 3.2 to 3.7 mm. wide at dormant stage to 4.2 to 6.5 mm. wide when tender foliage leaves begin to appear at the tips of the bud as for instance when bud development reaches that of figures 2 and 3 of Plate 2.

Foliage leaves.—At their dormant stage, the foliage leaves, as they naturally appear, of both terminal (16 to 20) and axillary (14 to 16) buds are more or less conically-shaped with tips apparently either pointed or blunt, the latter especially true with those of the axillary buds.

The terminal foliage leaves are set more or less squarely on the stem end, the length of these organs decreasing as they go towards the inside or center. They range from 1 to 4 mm. long and from 0.5 to 1.5 mm. wide (Plate 1, figs. 6 and 18).

Dissecting one by one the foliage leaves and examining them closely with the aid of a dissecting microscope would reveal profuse hair at the central ventral portion of each foliage leaf (Plate 1, figs. 8–9 and 19–20). The hairs may both be unicellular or multicellular, mostly of the latter type (Plate 1, figs. 10 and 12). After the removal of the foliage leaves (or foliar primordia) the crown is bared in a short cone-like structure (Plate 1, figs. 7 and 15).

Differences between floral and foliar shoot buds—active—Macroscopical).—Numerous studies and dissections of both kinds of shoot buds reveal a number of interesting points. The most apparent difference at first glance (on advanced stages of buds)

is the extremely "beak-like" and usually very plump appearance of the floral shoot (Plate 2, figs. 5–6) which retains such an appearance for sometime even when the scales have already fallen off and the abortive foliage leaves have fully attained their development (Plate 2, figs. 6 and 10). These foliage leaves which do not even attain one-eighth the size of a normal leaf (Plate 2, fig. 10) fall off upon further development of the flowers they subtend, the leaves serving as primary bracts.

The foliar shoots grow either upright or, if "beak-like," they are not so pronounced as the floral shoots. Moreover, the foliar shoots are quite lean in appearance (Plate 2, fig. 3 and Plate 3, fig. 1). This characteristic is especially true with terminal shoots.

As is clearly shown in the above discussion, such differences become discernible only when the growth of the buds is already quite advanced. At the dormant stage of the buds and even at just the start of differentiation there seems to be no way of differentiating the two kinds of buds unless microscopic studies are carried out and even at that only when floral cluster primordia are already distinguishable.

At the outset, it must be mentioned that examinations of dormant buds, both terminal and axillary, never show any difference until the buds are already on the advanced stage as shown in Plate 2, fig. 5. At such advanced stage, although the two or four outermost scales of the floral bud are not any different from those of the foliar bud, the succeeding scales (inner) show distinct characteristics. Those of the floral shoot (bud) are slightly broader especially those on the dorsal side of the beak-like formation. They are tough, rigid, triangular, and quite vaginate (Plate 4, figs. 1–17a) while those of the foliar shoots are usually slightly ovate or ovate-deltoid (Plate 3, figs. 2–16) and less tough.

It may be mentioned that on both shoot buds, the inner scales emerge only after growth has started for some time (Plate 2, figs. 2–3 and 5–6)). Also, in both cases the laminar primordia slightly decrease towards the inside (that is, longer on the outer scales and shorter for the inner scales) until the transition scales are reached (Plates 3 and 4, figs. 2–13), the latter having relatively longer ones. When the foliage leaves are reached (Plate 5, figs. 18–47), the sheaths are much reduced or are no longer noticeable. These structures become the true leaves upon further development.

Observations on many dissected buds have shown in many cases that floral shoot bud inner scales are quite similar to those of the foliar shoot bud, the decrease of the foliar primordia (protuberances) being irregular.

The flower or rather flower cluster primordia arise from the 5th or the 6th scale at its axil (Plate 2, fig. 8) and continuously up to and in the arrested foliage leaves (Plate 2, fig. 9). These inner scales and the abortive leaves become bracts subtending the lateral branches of the inflorescence or flower panicle. Both scales and leaves may fall off upon further development of the whole inflorescence. In the foliar shoot bud there are no outgrowths at the axils of the scales as borne out by observations, axillary buds being found only emanating at the axils of the true leaves (Plate 3, fig. 1).

Microscopical.—Plate 6, figs. 1 and 4 show median longitudinal sections of buds before smudging. Figure 1 (from trees 8, 9, and 10), figure 2 (from trees 2, 4, and 6), and figure 3 (from trees 3, 5, and 7) were taken on November 10–28, 1933 at Novaliches, Rizal. During the latter part of December the samples of buds taken appeared as in figure 4 (dormant stage). Note that up to this stage there is no way of telling whether the bud is to bear flower or not. Such a bud is potentially a leaf or a flower bud. This corroborates the findings of Lazenby(17) and Goff(10)(11)(12) who, in their studies on buds of apple, pear, plum, and other fruit trees found that during the early part of the growing season the structures and development of potential blossom and potential leaf buds are similar. The apical meristem is quite small and narrow although raised.

Finding that in 1933–1934 very few buds flowered, especially those of the selected trees at Novaliches and Central Experiment Station, smudging was resorted to during the 1934–1935 flowering season for observation, as soon as the twigs and leaves bearing the buds were well matured. The result is shown in Table 1. Table 2 shows the observation obtained in 1937.

TABLE 1.—*Period of bud differentiation as noted in 1934.*

Tree number	Date smudging begun	Differentiation first noted (microscopic)	First appearance of flower formation (naked eye observation)	Complete differentiation (microscopic)
1	Nov. 3, 1934	Nov. 18, 1934	End of November, 1934	Dec. 1–3, 1934.
2	Nov. 3, 1934	Nov. 8, 1934	End of November, 1934	Dec. 1, 1934.
3	Nov. 3, 1934	Nov. 8, 1934	End of November 1, 1934	Dec. 1, 1934.
4	Dec. 10, 1934	Dec. 15, 1934	First week of January, 1935	Jan. 7, 1935.[a]
5	Dec. 10, 1934	Dec. 19, 1934	First week of January, 1935	Jan. 7, 1935.[a]

[a] Buds attacked with fungus before complete differentiation was attained.

TABLE 2.—*Period of bud differentiation as noted in 1937.*

Tree number	Date smudging begun	Differentiation first noted (microscopic)	First appearance of flower formation (naked eye observation)	Complete differentiation (microscopic)
1	Oct. 27, 1937	Nov. 1, 1937	Second week of November, 1937	Nov. 15, 1937.[b]
2	Oct. 27, 1937	Nov. 5, 1937	End of 2nd week of November, 1937.[a]	
3	Oct. 27, 1937	Nov. 2, 1937	End of 2nd week of November, 1937.[a]	
4	Oct. 27, 1937	Nov. 10, 1937	Second week of November, 1937	Nov. 20, 1937.[b]

[a] Destroyed by the typhoon of November 11, 1937.
[b] Partly damaged by the typhoon of November 11, 1937.

It may be seen from the preceding tables that the range in smudging is from 6 to 17 days before any differentiation is noted (microscopically) and about 2 to 3 weeks before one could see with the naked eye the profuse formation of flower panicles. In 1934 the profuse appearance of flowers occurred in November for those smudged on November 3, while in 1937 the appearance was during the second week of November, the smudging having been done on October 27 as the trees were then ready and the weather favored the operation.

The dormant buds, based upon numerous dissections, whether they be examined any time between May and November, are composed of 28 to 36 pieces or parts, the outer 7 to 9 being scales followed by 1 to 3 transition scales which in turn are followed (towards the inside) by 20 to 24 foliage leaf primordia. With growth activity, whether the bud is smudged or not, tissues that appear as thickening (Plate 6, fig. 8) and later as protuberances (Plate 6, figs. 10–11) at first arise at the axils of from the fifth scale to the foliage leaves. Later, they become "club-like" in appearance. These are the flower cluster primordia (Plate 7, figs. 1–8). At this stage the inner scales (including the transition scales) as well as the foliage leaves serving as primary bracts have already expanded. When the floral shoot develops further these scales and bracts progressively fall off from the outer to the inner portions. This is also true of the scales of the foliar shoot, they being without leaves that serve as bracts but the foliage leaf primordia become normal leaves upon development.

The first indication of bud differentiation is the enlargement as well as the broadening of the axil in the region of the crown (cr.). At the same time there occurs an increase in size and greater elevation of the apical meristem (am) or growing point (Plate 6, fig. 5). For the purpose of this write-up let this be

called *Stage I*. Later, growth thickening appears at the axil of the fifth scale and so on in the case of the floral bud. This growth occurs on the 6th to the 10th and sometimes on the 17th day of smudging. *Stage II*. (Tables 1 and 2). For relatively younger buds the range is greater being about 11 to 17 days or possibly, even more.

An examination of sections shows that from 12 to 18 days and sometimes after 22 days, the apex slightly flattens preparatory to the formation of the terminal flower cluster primordium. By this time the first axillary flower cluster primordia begin to differentiate further showing more elevated protuberances (Plate 6, figs. 10–11). *Stage III*.

After 19 to 28 days of smudging, there appears in the terminal flower cluster primordium a sepal-like structure which may be further lateral flower cluster (Plate 7, fig. 8). Incidentally the first axillary flower cluster primordia show the formation of the branching of the panicles, with the first flower seeming to begin to differentiate (Plate 7, figs. 3, 4, 7, 8). *Stage IV*. This procedure of development is continued in each cluster, the lowest clusters always being more mature than the upper.

It may be mentioned that incident to this study, the development of flowers was observed. It shows that the floral parts develop in succession, viz., calyx, corolla, stamens, pistil, and finally the ovules. The findings of Juliano and Cuevas(15) on the Pico variety are, therefore, corroborated.

DISCUSSION

A study on bud differentiation in mango trees as well as on signs of pre-floral (at dormancy) formation is of great importance not only for scientific reason but also for practical and economic purposes. Smudging expenses to force mango trees to flower are often high; sometimes beyond the means of the grower. The present article endeavors to establish the differences between floral and foliar buds. It also tries to establish pre-floral characteristics that would enable one to determine which tree would bear profuse flowers with the least smudging even basing one's judgment only on the characteristics of the dormant buds.

External and internal changes in buds from dormancy up to the formation of flowers have been noted. Likewise the lapse of time or period in which flowers are formed in smudged and in unsmudged trees were recorded.

Studies on pre-floral characteristics have already been the subject of various investigations. For instance Goff(10)(11) considered the slight irregularities in the growing point or crown of buds as first evidence of differentiation while Drinkard(6) considered corrugations of the crown of the bud as the first morphological evidence that a differentiation into flower buds had taken place. Likewise, Kraus(16) considers the thickening of the flower axil as the first observable indications of the flower and Bradford(4) working on apple states that the first evidence of fruit bud formation is the rapid elevation of the crown into a narrow conical form, rounded at the apex, with the fibrovascular connections and pith areas advancing concurrently. Tufts and Morrow(18) working on almond, apple, apricot, cherry, peach, pear, and plum maintain that the definite broadening and thickening of the axils of buds are evidences of first differentiation in floral parts. They state that the formation of protuberances which eventually become the calyx, corolla, stamens, and pistil follows immediately.

Taking up the present work, it is apparent that prior to smudging, or at the dormant stage of the buds, no pre-floral characteristics that would show whether a tree is going to have profuse flowering or not, have so far been observed. For instance in 1933 the trees in Novaliches (without smudging) did not develop many flowers even up to February, 1934. Instead of flowers, leafy shoots were in more instances formed. Although it has been observed that buds from twigs with leaves that are light copper colored, mature, brittle, and leathery need a shorter period of smudging before flowers are developed, yet, one cannot be sure that such buds would, in the majority of cases, yield floral shoots especially when no smudging is done. This of course brings out the necessity of smudging. Hence such smudging was carried out in the latter studies.

The first external manifestation of the activity of dormant buds (with or without smudging) is the gradual loosening of the scales and the corresponding elongation or growth of the inner scales. This is clearly manifested by a well defined greenish area which was once covered by the several outermost scales. Such growth is shown after 6 to 17 days of smudging. For similar buds on unsmudged trees taken as subject of studies with the smudged ones none of such activities were observed within one and sometimes even within one and one-half months.

Observations show that even in buds of similar stage of dormancy, such growth or activities do not occur at the same period. Some manifest the signs after 6 days, others after 7 days, etc. These observations point to the obviousness of smudging operations.

Externally, it has been observed that buds which are to form flowers, show greater radial thickening due possibly to the growth of protuberances (flower cluster primordia) at the axils of the inner scales, beginning with the fifth scale, and the foliage leaves. As clearly noted from dissections (Plate 2, fig. 7) and from microscopic examination (Plate 7, figs. 3–8), such growth as fig. 5 of Plate 2 for instance is shown only as a result of the activities at the axils of both the scales (Plate 2, fig. 8) and foliage leaves (Plate 2, fig. 9). Moreover, buds that give forth inflorescences exhibit patently a "beak-like" appearance due to greater growth of scales and flower (cluster) primordia on one side (Plate 2, figs. 2, 5, 6, 7).

The results obtained from several trees at the Central Experiment Station at Singalong show that whenever such "beak-like" appearances (Plate 2, figs. 5–6) are seen in most buds, smudging is no longer necessary as the flowers must have had undergone differentiation already by then. It is important to know this characteristic as stopping smudging at this stage would result in considerably reduced expenses. Such formation (beak-like) persists for sometime even after the foliage leaves serving as bracts are fully developed (Plate 2, fig. 10). These scales and foliage leaves fall off as further growth and development of the flowers ensue.

At this juncture the question, can such appearance (beak-like) be exhibited without smudging arises? A systematic and thorough observation reveals these facts to be apparent: (1) that early flowering of mango could be enhanced by smudging, (2) that profuse flowering is made possible only through such operation, (3) that some trees may also flower even without smudging, although not as profusely as when they are smudged. The floral shoots that arise on unsmudged trees show this trait to be present in them. However, such floral shoots on unsmudged trees are not only relatively scanty but are late-comers. In the course of this work, for instance, while smudged trees in November bore profuse flowers in the same month those unsmudged in nearby places flowered in January–February and only few inflorescences were formed at that. Incident to this study

therefore one thing stands clear, and that is to force the trees to yield fruits early through smudging in order to command good prices.

From histological observations of buds, both from smudged and unsmudged trees, the writer is inclined to believe that changes from dormancy to the floral shoot bud stage occur as relatively sudden changes. With unsmudged trees for instance, no differentiation was observed from November to about December 20. Suddenly, examinations of buds 3 days thereafter showed some protuberances in some of them in appearance similar to those shown in Plate 6, fig. 9 (of the smudged trees).

Histological examinations of buds—both floral and foliar—show practically no differences in the few outermost scales, but certain differences are apparent in the inner scales. In the case of the foliar shoot bud, the inner scales exhibit certain changes in the shape of the sheaths as well as in the size of the laminar primordia. As already mentioned elsewhere, during the dormant stage of the bud the scales are more or less triangular. With the commencement of growth, however, the inner scales become ovatus-deltoídeus (ovate-deltoid) with the innermost two or three scales (excluding transition scales) slightly obovate. The laminar primordia become shorter and shorter up to the transition scales, where, again they become relatively longer. The sheaths of the transition scales elongate considerably with slight winged outgrowths as beginnings of laminar primordia at their adaxial sides. Such outgrowths are not so apparent unless the sheaths are well spread and clearly examined. The successive structures correspondingly show an increase in laminar development which will eventually result in distinct young leaves.

In the case of the floral shoot, dissections and examinations of numerous buds show that, although the scales are triangular to begin with, and with inner scales also ovate-deltoid or oblong upon further growth, because of greater development on one side than on the other (forming "beak-like" appearance of the bud), the increase in size of the sheaths is irregular as found by dissection in succession of the scales (Plate 4, figs. 4–16). The shapes are also quite irregular. Some sheaths are almost rounded (Plate 4, fig. 13), others quite obovate (Plate 4, fig. 16). The transition scales are generally relatively longer and broader than the foliar and with curvature tipping at one side (Plate 4, figs. 15a and 17a) due to uneven development of the bud. The

cause of such an unevenness has not been included in this study. Although not always, the inner scales do not show very distinctly the laminar formation. They serve as primary bracts that subtend the lateral branches of the floral cluster (Plate 2, fig. 8 and Plate 7, fig. 5).

Through microscopic examination it has been noted that after 6 to 17 days of smudging (on smudged trees), activities are shown both in the lateral and the apical meristem. In case of foliar shoots, such activities become manifest only at the apical meristem.

SUMMARY

1. This paper gives the results of studies on bud differentiation in smudged and unsmudged Carabao mango trees at Novaliches, Lamao, and Singalong.

2. Results seem to establish no definite pre-floral characteristics to enable one to predict whether or not dormant buds would develop either into flowers or leaves.

3. Although observations did not exactly establish any definite characteristic it was observed that buds from stems with leaves that were light copper, mature, brittle, and leathery required comparatively shorter period of smudging than those from slightly younger stems before flowers were developed.

4. Smudging apparently shortens the dormancy of buds. It took only 6 to 17 days after smudging to show signs of differentiation.

5. Externally, the first manifestation of the activity of the bud whether smudged or not is the loosening of the scales and the elongation and slight broadening of the inner scales showing marked green color of the inner scales once covered by the few outermost ones.

6. The external sign of a bud (already in an advanced stage) about to form floral shoot is its greater radial thickening, perhaps as a result of the growth of flower cluster primordia at the axils of the inner scales and the foliage leaves. With further development the floral shoot exhibits a patently "beak-like" appearance due to greater growth on one side of the bud. When such a stage is reached it is quite safe to stop further smudging as the flowers by then have already differentiated. This greatly lessens the cost of smudging.

7. Microscopic examination of buds shows that growth activity on apical meristems, in the axils of the scales (from the 5th inwards) and in the foliage leaves occur in 6 to 17 days of con-

tinuous smudging. The period is shorter for the older dormant buds. Buds from relatively young twigs require a longer period of smudging before some flowers develop.

8. The inner scales of foliar shoots are triangular at first, but become ovate-deltoid when activated with laminar primordia, decreasing in size up to the transition scales when again such protuberances (laminar primordia) become very apparent, while the transition scales become long and narrow.

9. The inner scales of the floral shoot are irregular in sizes due to the greater growth on one side (forming beak-like appearance), those on the "dorsal" side being bigger than those on the "ventral" thus giving the beak-like appearance of the bud. As a whole the scales are relatively bigger and broader than those of the foliar shoots. The shape is also broadly ovate-deltoid, in some cases almost rounded.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Side view of a typical dormant terminal bud. (A) base of petiole. (B) Scale. (×8)
2. Dorsal view of an outer scale of a terminal bud. (×8)
3. Ventral view of an outer scale of a terminal bud. (×8)
4. Dorsal view of a transition scale of a terminal bud. (×8)
5. Ventral view of a transition scale of a terminal bud. (×8)
6. Showing the cone-like structure of the foliar primordia after the removal of the scales. (×10)
7. Showing the slightly elevated tissue after the removal of scales and foliar primordia from a dormant bud. (×14)
8. Dorsal view of a foliar primordium that later becomes an abortive true leaf and serves as a primary bract of a flower panicle, or a leaf in case of a foliar shoot bud. (×14)
9. Ventral view of (8) showing the numerous hairs. (×14)
10. Showing the structure and form of a multicellular and a unicellular hairs of the foliar primordium. (H. P.)
11. Dorsal view of a typical dormant axillary bud. (A) base of petiole. (S) Scale. (×8)
12. Showing the structure and form of the hairs on foliar primordia. (H. P.)
13. Dorsal view of an outer scale of an axillary bud. (×8)
14. Ventral view of an outer scale of an axillary bud. (×8)
15. Showing the slightly elevated tissues after scales and foliar primordia are removed. Note the slightly compressed condition. (×14)
16. Dorsal view of a transition leaf of axillary bud. (×8)
17. Ventral view of a transition leaf of an axillary bud. (×8)
18. Showing the cone-like formation of the foliar primordia of an axillary bud. Note the shorter length of those at the left side (due to the slight compressed condition) as normally growing at the axil of the leaf. (×10)

19–20. Dorsal and ventral views of a foliar primordium. This organ becomes the abortive true leaf of a flower bud, or a well-developed normal leaf of a foliar bud. (×10)

PLATE 2

FIG. 1. A diagram showing the organography of a dormant terminal bud. (S) scale, (TS) transition scale, (F) foliar primordium, (am) apical meristem. (×8)
2. An advanced stage of a terminal floral bud. (×6)
3. An advanced stage of a foliar shoot bud. Note its leaner appearance and the tendency to have a rather straight growth. (×3)
4. A terminal bud getting to be active after 7 days of smudging. (P) base of petiole, (S) scale. (×8)

FIG. 5. A terminal bud after 14 days of smudging showing plumpness and the tendency to have a "beak-like" formation. These are signs that the bud is a flower bud. (×6)

6. A terminal bud (more advanced than 5) showing the pronounced beak-like formation of a floral shoot bud. (×2)

7. A floral shoot bud after the scales and foliar primordia are removed. Note the flower cluster primordia (FP). (×14)

8. Ventral view of an inner scale bearing a flower primordium. (S) scale, (FP) flower cluster primordium. (×2)

9. Ventral view of a true leaf bearing a flower cluster primordium at its base. (FL) foliage leaf, (FP) flower cluster primordium. (×2)

10. An advanced floral shoot with scales fallen and with leaves that are well differentiated but are of arrested growth and serving as primary bracts. These leaves sooner fall off also developing flowerets (F). (L) leaf. (×1)

PLATE 3

FIG. 1. A foliar shoot bud with scales all removed to show the lean appearance of stem. (×2.5)

2–13. Scales of a foliar shoot bud. Note the increasing sizes of scales towards the inside of the bud. Note further the decreasing sizes of the protuberances at tips (laminar primordia). (×2)

14–16. Transition scales of a foliar shoot bud. Note their narrowness and great elongation. Note further the laminar primordia. (×2)

PLATE 4

FIGS. 1–14. Scales of a terminal bud at a stage as of Plate 2, fig. 2. (×2)

15–17. Transition scales of the same terminal bud. (×2)

15a–17a. Transition scales of a typical terminal floral bud at full development as of a stage as that shown in Plate 2, fig. 2. (×2)

PLATE 5

FIGS. 18–47. Showing the beginning of the greater development of the primordia that become the true leaves but of abortive development; becoming primary bracts of flower panicles. Note the apparent alternation of sizes due to the greater development at one side of the floral shoot resulting in "beak-like" appearance. Note also the arrested development of the sheaths. (×2)

PLATE 6

Median longitudinal sections

FIG. 1. A very young bud as appearing on number 10 from shoots that appeared at the end of October. (cr) crown of bud, (S) scale. (×45)

2. Showing the growth of buds as in Fig. 1 after 6 days. Note the primordia (p) arising from the apical meristem. (×45)

3. Showing further growth of the bud as of Fig. 2 after 12 days. (×45)

FIG. 4. A bud at about the incipient (dormant) stage before smudging. (×45)

5. A bud after 6 days of smudging. Note broadening of apical meristem (am). (×45)

6. Showing the beginning of the activity of the tissues at the axils (a) after 7 to 16 days of smudging. (×45)

7. Further activity at the axils. Note greater development of the vascular bundle (vb). (×45)

8–11. Further successive growth of the primordia at the axils. Figs. 10 and 11 show the differentiation of the floral buds as shown by the growth of the primordia at both the axils of the scales (S) and leaf primordia (LP). (×45)

PLATE 7

Median longitudinal sections

FIGS. 1–2. Further development of flower cluster primordia at axils of both scales and foliage leaves. (×45)

3–5. Floral shoot bud development (originating from axillary buds). (S) scales, (FP) flower cluster primordium, (LP) leaf primordium after 19–28 days of smudging. Note formation similar to terminal buds. (×45)

6–8. Floral shoot bud development (originating from apical buds). (FP) flower primordium, (S) scales, (LP) leaf primordium. Note formation of sepal-like structure (se) 14–25 days after smudging, which may become first flowerets. (×45)

9. Showing buds that have not changed much even after 4 weeks of smudging. Note however that there seem to be formation of bud primordia at axils (see thickening) of the foliage leaves. They may eventually give rise to axillary buds. (×45)

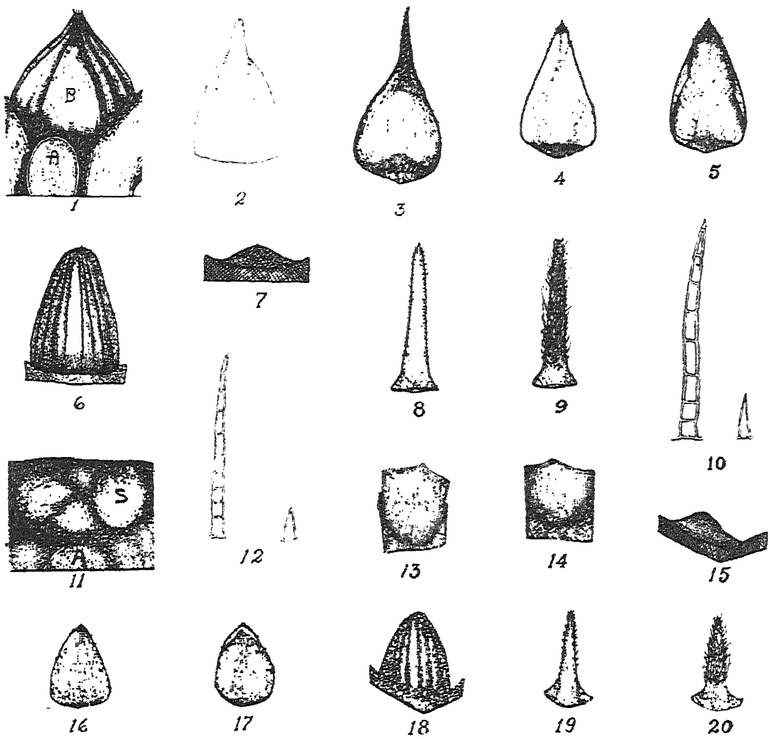
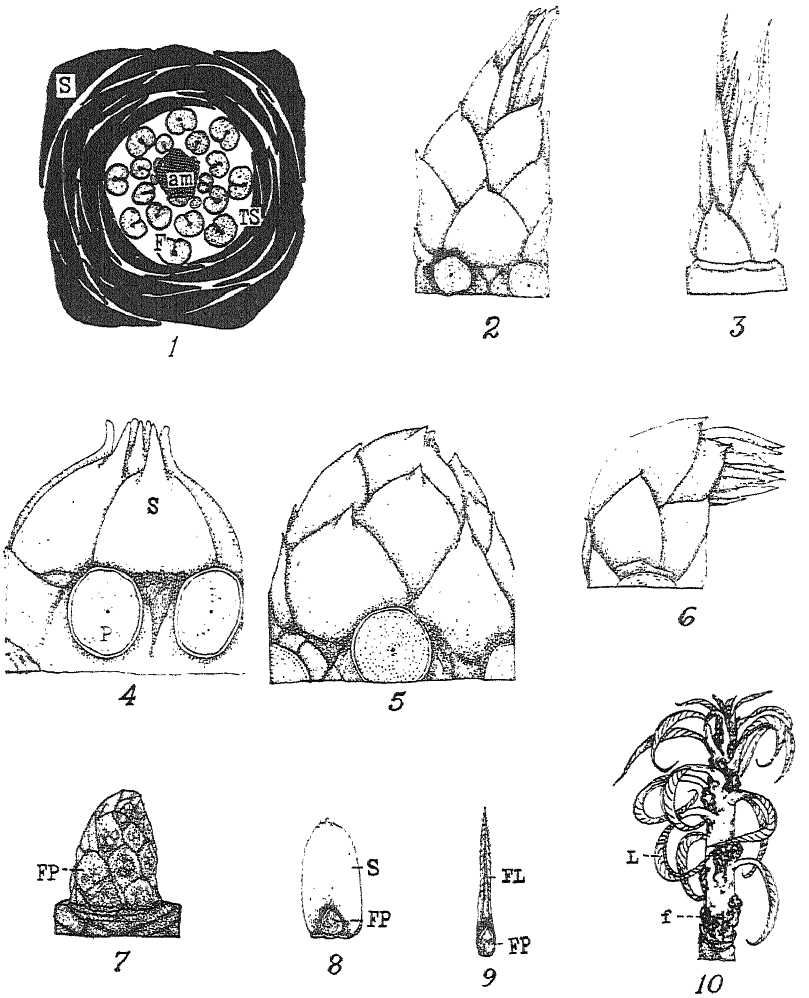


PLATE 1.



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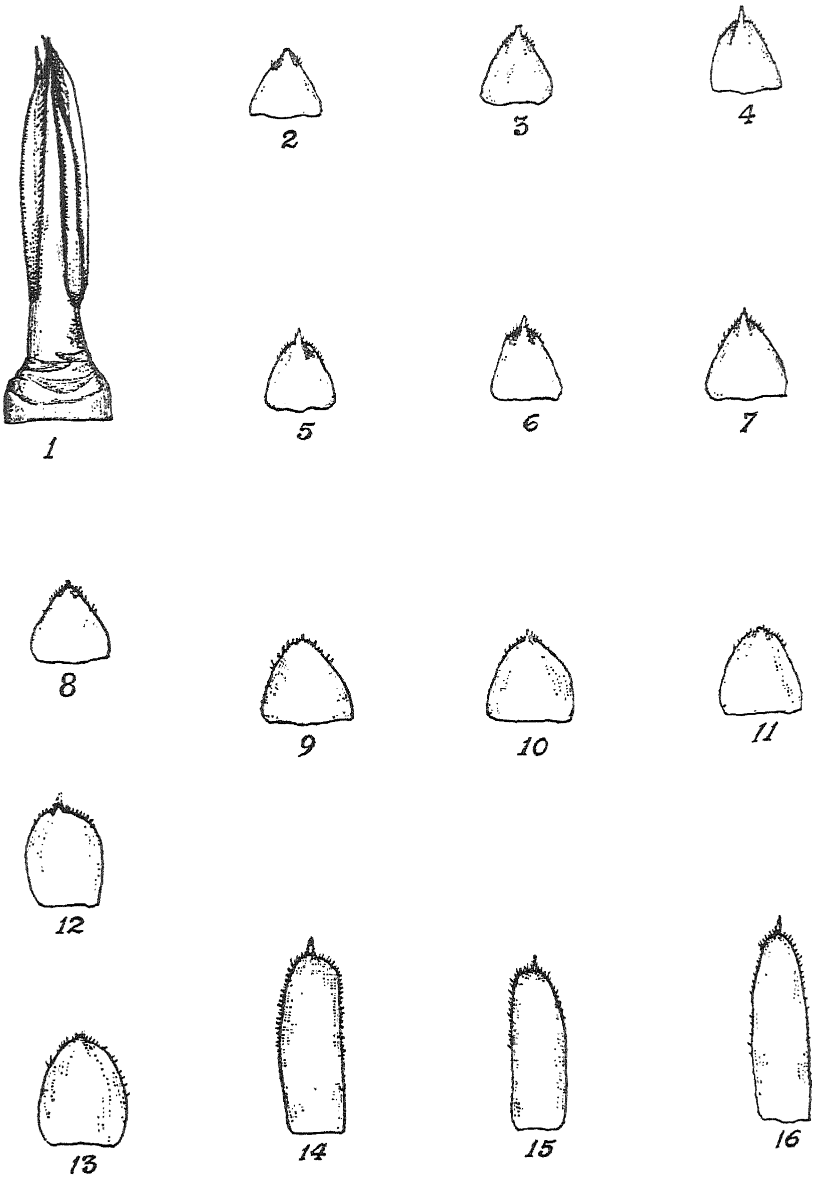
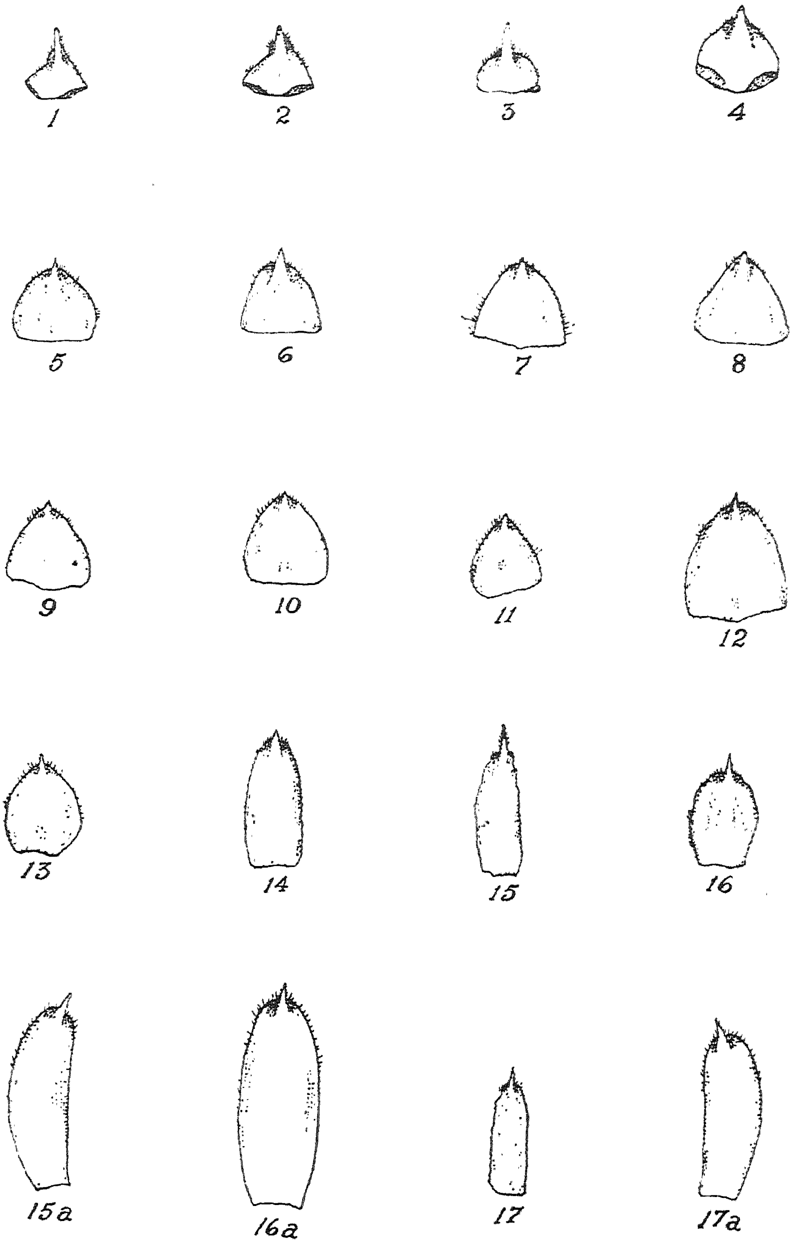


PLATE 3.



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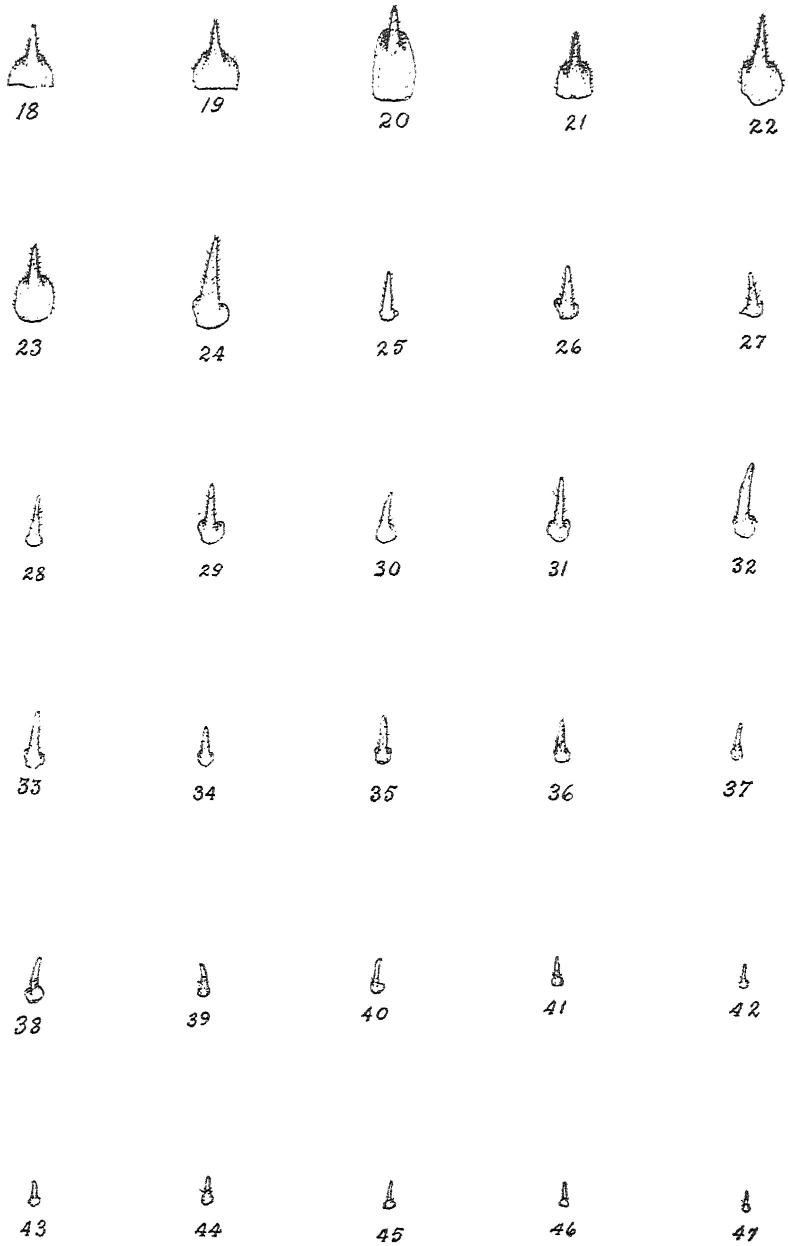
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PLATE 5.

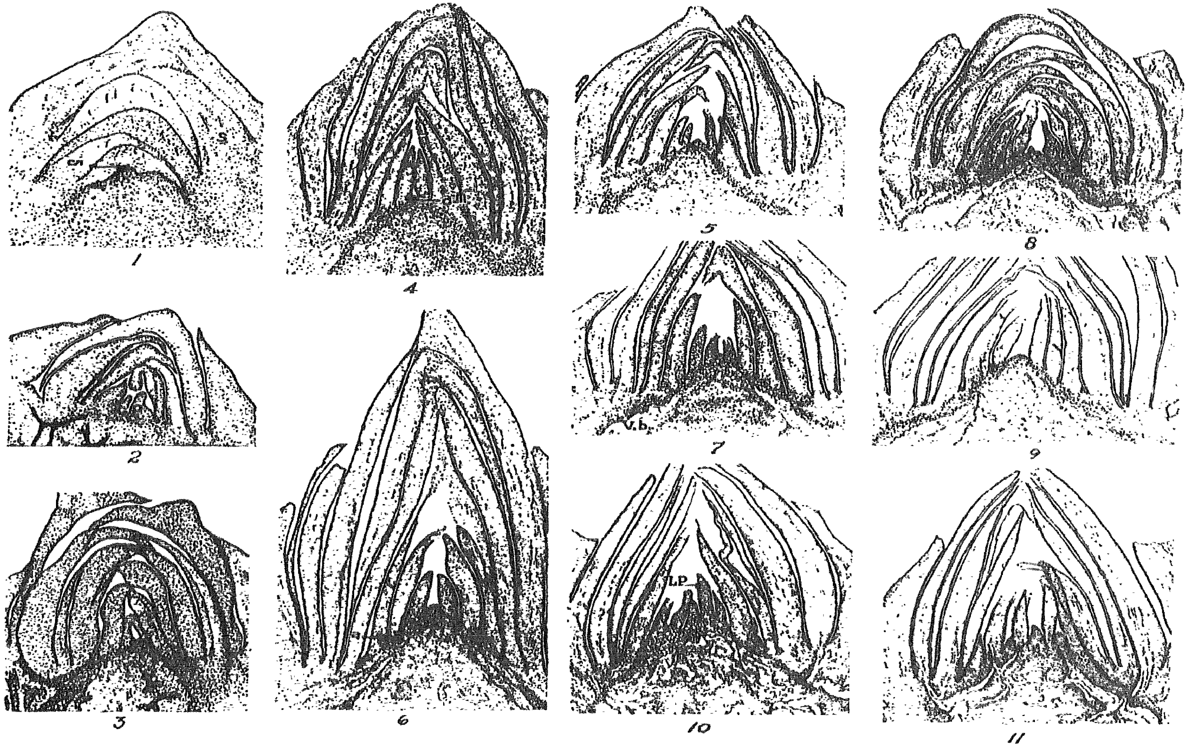

PLATE 6.

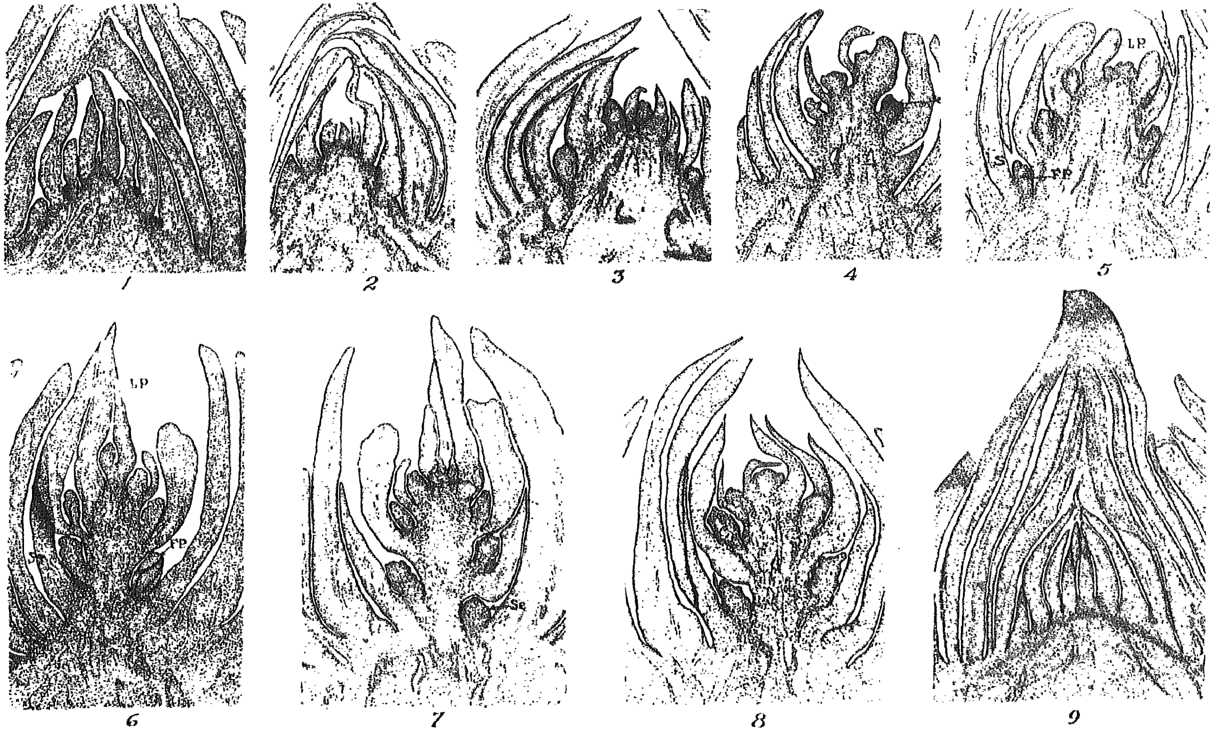

PLATE 7.

THE RICE CADANG-CADANG IN ALBAY PROVINCE: I. ITS PROBABLE CAUSE

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SEVEN PLATES

The so-called rice *cadang-cadang* in Albay first elicited the attention of the Bureau in the early part of 1935, through Hon. E. Kare, then Assemblyman for Albay who reported the malady to the Bureau of Plant Industry. Mr. Pedro L. Sison, assistant agronomist, being in Albay at that time was commissioned to investigate the malady. After surveying a total of about 32 hectares of affected fields in the towns of Camalig, Guinobatan, Ligao, Oas, Polangui and Libon, Mr. Sison entertained the suspicion that *cadang-cadang* might be due to two causes, to wit, damaged roots due to certain fungus attack and starvation caused by depleted condition of the soil.

Since the initial outbreak of the malady, apprehension has been rife among farmers of Albay who fear the possibility of its spreading throughout the entire province. Every now and then letters keep pouring into the Bureau inquiring of the proper methods of control. In response to the said requests, a party composed of Messrs. Gaudencio M. Reyes, Rufino Isidro, and Julian A. Agati, all of the Bureau of Plant Industry was sent to Albay in November, 1935 to conduct an extensive survey and thorough study of the malady. Among other things, the junior author found the following:[1]

1. *Symptoms of rice cadang-cadang.*—The plants affected by *cadang-cadang* manifest a decided yellowing of the leaves and are generally stunted in growth. The older leaves become light orange or yellow and only the inner younger leaves remain green. The dwarfing of the plants is probably due to the persistent yellowing and eventual drying of the leaves. The yellowing starts from the outer leaves and works inward to the inner young leaves. The roots of the plants are mostly brown; only those extending horizontally from the base of the plants are white and turgid.

[1] A manuscript, entitled "Preliminary Studies on the So-Called Rice "Cadang-Cadang" in the Bicol Provinces" is on file in the Bureau of Plant Industry, Manila.

2. *Extent and distribution of the malady.*—*Cadang-cadang* was observed in patches throughout the regions west of the Mayon Volcano, extending from Polangui to Camalig in the south. The malady was present in both irrigated and unirrigated paddies where the surface soil is generally shallow and sandy, measuring about 4 to 5 inches deep. The sub-soil is predominantly sandy to gravelly.

3. *Seasonal occurrence of cadang-cadang.*—*Cadang-cadang* appears in July or August, or about a month or so after transplanting which is usually done in May or June. The effects of the malady on Baranay, the variety of rice commonly planted in Albay, become evident about July or August or a month or so after transplanting.

4. *Actual conditions of the rice paddies.*—The rice paddies in Albay are generally weedy. However, *cadang-cadang* appears irrespective of whether the paddy is weedy or not. In the weedy paddies, eight different kinds of weeds were identified by Mr. L. Karganilla of the Bureau of Science, though only two are common and persistent. The first is called *San Jacinto* (*Ischaemum rugosum* Salisb. var. *distachyum*) and the second is the *balangot* (*Cyperus pilosus* Vahl.). Since these weeds are promiscuous growers they often choke out the rice seedlings in the paddies.

5. *Results of soil analysis.*—To get a clear idea of the nature and composition of the soil where *cadang-cadang* thrives, soil samples were analyzed. The results of the analysis are shown in Table 1.

TABLE 1.—*Analysis of the constituents of soil taken from Polangui, Libon, Oas and Camalig, Albay* [a]

Constituents	Normal soil	Cadang-cadang soil
	Per cent	*Per cent*
Nitrogen—total	0.266	.175
P_2O_5—total	.306	.231
Available [b]	.052	.052
K_2O—total	.428	.426
Available	.011	.010
Ca_2O—total	5.92	7.47
Available	.72	.33
Fe_2O_3—total	9.16	9.64
Available	0.68	0.44
Al_2O_3—total	20.56	18.50
Available	0.78	.91
Mg_2O—total	2.83	3.07
Available	.082	.082
SO^3—total	.381	.550
Available	.044	.033
Alkalinity as $CaCo_3$—total	0.815	.836

Table 1 shows very clearly the presence in very little amounts of the principal plant food elements usually deficient in the soil, namely, nitrogen, phosphorous and potassium.

[a] Analyzed by Mr. Rufino Isidro and reported to the Bureau of Plant Industry.

[b] Available determination = Soluble in 1 per cent acetic acid and all other figures are on water-free basis.

6. *Results of pot culture studies summarized.*[5]—The addition of sulphate of ammonia, double superphosphate of lime and sulphate of potash separately to each canful of *cadang-cadang* and normal soils planted to rice plants at the rate of 200 kg. per hectare did not only improve the general stand and growth of the plants but also augmented the yield. The trend of results obtained seems to point to the probability that the rice *cadang-cadang* complex in the Bicol region might be linked with the deficiencies in available soil nutrients in the soil like phosphorous, nitrogen and to a slight extent, potash (Plate 1).

DEMAND FOR FURTHER STUDY

The appearance of rice *cadang-cadang* to an alarming extent in the Bicol region in the year 1937 made the farmers reluctant to grow rice in their fields the following season. This attitude of the farmers prompted the Director of Plant Industry to appoint a committee in December, 1937 to extend the study thus far conducted by the junior author that remedies or control measures may be devised. The committee is composed of Dr. Fernando de Peralta, chairman, Messrs. J. A. Agati, V. Borja and R. Isidro, members.

PLAN OF STUDY

Based on the results of soil analysis submitted by Mr. Rufino Isidro and the results of pot cultures summarized in this paper, the study of rice *cadang-cadang* was undertaken in the light of the following questions:

1. Does the soil sample known to cause rice *cadang-cadang* in the Bicol provinces produce the symptom of *cadang-cadang* on rice when placed in petroleum cans watered regularly with Manila water supplied by the Manila Metropolitan Water District?

2. Is *cadang-cadang* due to the activity of soil fauna connected with plant food consumption or due to "locked" up condition of plant food nutrients present in the soil?

3. Is *cadang-cadang* not the result of food deficiency in the soil and, if it is, which of the three principal food elements, namely, nitrogen, phosphorous and potassium is the limiting factor? The answers to these questions were worked out simultaneously and are being presented in this paper as Experiments 1, 2 and 3. The experiments were conducted in the premises of the laboratory of the Tobacco Research Section from December, 1937 to August, 1938.

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[5] The results are taken from an unpublished manuscript now on file in the Bureau of Plant Industry, Manila. The soil used in the studies was obtained from Albay province. Baranay which is commonly planted there was used in the experiment.

MATERIALS, METHOD AND RESULTS

SOIL

Sufficient soil samples obtained at random from a *cadang-cadang* infested field and from adjacent non-infested places to fill no less than thirty petroleum cans each were taken from Mayao, Oas, Albay in December, 1937. The composite samples were brought to Manila for laboratory study. The samples were clay-loam, dark gray and showed all the appearances of a fertile soil. They were placed separately in the greenhouse to dry. Each soil sample was mixed thoroughly with the use of spade and fork. For convenience, the *cadang-cadang* infested soil and the normal soil (*cadang-cadang* free) are designated in this report as C–soil and N–soil, respectively.

Experiment 1.—Five empty petroleum cans were filled to about 15 centimeters from the rim with C–soil. Enough tap water was poured into the container to bring the moisture saturation of the soil to about 70 per cent. Seeds of the variety of rice Baranay were sown and spaced 15 cm. apart in the can. Four hills of five seeds to a hill were planted in every container. The cultures were then placed outside of the laboratory in order to receive the full impact of the environment. The cans were set in a row and spaced 15 cm. apart. When the seeds had fairly germinated and attained a height of about 10 cm., the number of seedlings to a hill was reduced to two. Only uniform seedlings were left. After the second week, the number was finally reduced to one to the hill so that in every culture can there were four plants only. From the seedling to the fruiting stage at least a depth of about five centimeters of water was maintained in the can. Watering was done as often as necessary with water taken directly from the faucet.

Using the N–soil as media, another set of cultures was prepared. The same number of cultures and treatment administered were utilized. The set was then placed alongside the C–soil cultures outside of the laboratory.

Experiment 2.—Experiment 2 was divided into two parts. The first part was conducted as follows:

(1) From the same soil stock used in Experiment 1, enough C-soil was taken and heated continuously to about 70° C. during a period of eight hours and thereafter heated for the same length of time and degree of temperature every three days for a period of six days. The three petroleum cans prepared for the purpose were then filled with the heated soil up to about 10 cm. from the rim. Other three petroleum cans were also filled with the same kind of soil (C-soil) but were not heated. Both sets (the heated and the unheated C-soil) were planted to rice and then treated as in Experiment 1. The operation was repeated except that the soil media employed was the N-soil.

(2) The second part of Experiment 2 was prepared as follows: Twelve petroleum cans prepared for the purpose were filled with soil as described in Table 2.

TABLE 2.—*Treatment of soil placed in petroleum cans for rice culture*

Culture number	Kind and treatment of soil in can	Source of water for watering
1, 2, 3	C-soil, unheated	Watered with aqueous soil extract of heated C-soil.
4, 5, 6	C-soil, heated [a]	Do.
7, 8, 9	N-soil, heated	Watered with aqueous soil extract of unheated C-soil.
10, 11, 12	N-soil, unheated	Do.

[a] The method of heating the soil used in this experiment was the same as that followed in the first part of Experiment 2.

After the cultures were prepared as described in Table 2, they were placed outside the laboratory. The treatments administered the cultures were the same as those described in Experiment 1.

Experiment 3.—C- and N-soils mixed separately with fertilizer mixtures as shown in Table 3 were put in 10 petroleum cans and planted to rice. The method and treatments given to the plants were exactly the same as those described in Experiment 1. The amount of each kind of fertilizer added to a canful of soil (based on surface area exposed) was computed at the rate of 150 kilograms per hectare. Other two cans each of C- and N-soils, without fertilizer, were also planted to rice. These cultures served as control.

TABLE 3.—*Amount of fertilizer mixture added to canfuls of C- and N-soils employed in experiment 3*

Fertilizer mixture	Number of culture	C-soil Amount	N-soil Amount
		grams	*grams*
1. Sulphate of Ammonia	2	8.25	8.25
Sulphate of Potash		8.25	8.25
2. Sulphate of Ammonia	2	8.25	8.25
Double superphosphate		8.25	8.25
. Sulphate of Potash	2	8.25	8.25
Double superphosphate		8.25	8.25
4. Sulphate of Ammonia	2	8.25	8.25
Sulphate of Potash		8.25	8.25
Double superphosphate		8.25	8.25
5. Sulphate of Ammonia	2	8.25	8.25
Sulphate of Potash		8.25	8.25
Double superphosphate		8.25	8.25
Sulphate of Magnesia		8.25	8.25
6. Experiment 1	No fertilizer applied (control).		

The results of this experiment are presented in Tables 4, 5, 6, 7, and 8. The growth behavior of the rice plants under the condition described in Experiment 1 will be presented first. The effect of heating the media and of watering the plants with aqueous soil extract upon the rice plants will then be discussed. Finally, the beneficial effect of adding commercial fertilizers upon the growth and yield of the rice plant will be given.

DISCUSSION OF RESULTS

EFFECT OF SOIL MEDIA

Cadang-cadang symptoms.—The leaves of rice plants grown in the C-soil (*cadang-cadang* infested soil) were much lighter green than the leaves of those plants in the N-soil (normal soil). The symptom of rice *cadang-cadang* observed in the field in the Bicol provinces was exhibited by the plants grown in the C-soil, but only to a lesser degree. This is attributed to the fact that the latter had better cultural treatment than those actually planted in the field. The unavoidable presence of weeds in rice paddies robs rice plants of soil nutrients and water. Such condition was absent in the can cultures.

Growth and yield of rice plants compared.—The plants in the C-soil were inferior to those grown in the N-soil. In spite of the fact that the plants in the C-soil were a little bit taller than those in the N-soil on February 4 (Table 4), they (the plants in

C-soil) were shorter upon reaching maturity. The beginning of the better growth and development of the plants in the N-soil was noted when the plants were forty days old (Plate 2), and this growth behavior continued until the plants were harvested on June 9.

Based on the yield of 4 plants as shown in Table 4, the N-soil produced heavier weight of grains and straw. An average of 27.6 ± 1.25 grams of grains was obtained from 5 cultures of N-soil as against 20.4 ± 0.51 grams from the C-soil. In straw, the former produced 62.4 ± 1.46 grams as against 45 ± 2.27 grams of the latter. It is apparent, therefore, that the C-soil as regards grain production was only 74 per cent as good as the N-soil. As a straw producer the C-soil was 28 per cent poorer than the N-soil (Table 4).

EFFECT OF HEAT AND AQUEOUS SOIL EXTRACT

Luxuriant growth of rice in heated soil.—The symptom of rice *cadang-cadang* did not appear on the rice plants grown in heated C-soil. Instead they showed increased growth and yield of grains and straw (Table 5). The favorable effect of heating the soil upon the growth of the plant as indicated in Plate 3 was noted also. The leaves were green, broad and long and the yield in grains increased from 20.5 grams (when the C-soil was not heated) to as high as 92.6 ±1.19 when heated (Table 5). The same trend of results was also observed in the N-soil. It appears probable, therefore, that the heat treatment given to the C-soil as described in the first part of Experiment 2 has changed, modified or ushered in a condition whereby the nutritive substances in the soil became available to the rice plants. This result seems to corroborate the finding of Gustofson(1) who says that heating soil with steam increases the solubility of P_2O_5 and nitrogen compounds. Steemkamp(2) and Mortensm and Dudley(3) claim that drying generally increases the solubility of soluble constituents of the soil.

Aqueous soil extract of C-soil does not produce rice cadang-cadang.—As described in Experiment 2 under Table 2, the aqueous soil extract of unheated C-soil was administered continuously to the rice plants grown in the heated and unheated N-soils. The plants did not produce the symptoms of *cadang-cadang* (Plate 4). The plants grown in the heated N-soil had dark green, broad and long leaves. Although the growth of the plants in the unheated N-soil was not as vigorous as those in

TABLE 4.—*Growth and yield data of four rice plants grown in a petroleum can (3.5 × 3.5 cms.) with cadang-cadang infested and non-infested soil (normal soil)*

Culture designation	Culture number	Date of observation and criteria studied: Feb. 4	Feb. 15	Feb. 25	March 7	June 9			Dry weight of grains	Dry weight of stalks	Presence or absence of cadang-cadang symptoms
		Height	Height	Height	Height	Height	Number of bearing culms	Number of non-bearing culms			
		cms.	*cms.*	*cms.*	*cms.*				*gms.*	*gms.*	
C-soil (cadang-cadang soil)	1	23.7	40.2	50.1	52.7	125	10	1	20	40	Present.
	2	22.2	38.8	49.0	56.2	120	11	0	22	51	
	3	19.3	35.0	44.0	51.0	130	10	6	20	41	
	4	21.3	41.6	45.2	49.7	131	9	2	18	38	
	5	21.7	39.2	49.5	53.3	127	11	4	22	55	
Average		21.6	38.9	47.5	52·6	126	10.2	2.6	20.4±0.51	45 ±2.27	
N-Soil (normal soil)	1	19.7	39.3	50.5	59.7	122	11	8	22	57	Absent.
	2	22.0	38.8	49.0	58.8	141	12	3	32	70	
	3	23.2	46.1	63.5	70.5	135	14	1	28	61	
	4	22.9	45.7	60.7	70.0	134	13	0	26	59	
	5	26.8	47.7	63.7	72.5	125	15	1	30	65	
Average		22.9	43.5	57.5	66.3	131	13	2.6	27.6±1.25	62.4±1.46	

DESCRIPTION:

C–Soil—The symptom of rice cadang-cadang observed in the Bicol region appeared during the growth of the rice plants, but to a lesser degree.

M–Soil—The plants were darker green than those grown in the C-Soil. Growth was slow, but the plants were normal.

TABLE 5.—*Growth and yield data obtained from four rice plants grown in petroleum cans with cadang-cadang infested and non-infested soil (normal soil), both heated*

Kind and treatment of media	Culture number	Date of observation and criteria studied							Dry weight of grains	Dry weight of stalks	Presence or absence of cadang-cadang symptoms
		Feb. 4	Feb. 15	Feb. 25	March 7	June 9					
		Height	Height	Height	Height	Height	Number of bearing culms	Number of non-bearing culms			
		cms.	*cms.*	*cms.*	*cms.*	*cms.*			*gms.*	*gms.*	
Cadang-cadang soil, heated to 70° C. for 8 hours, three times at 3 days interval.	1	21.8	45.0	53.9	81.0	161	48	18	96	288	Absent.
	2	23.2	45.7	58.3	76.0	170	50	20	92	280	
	3	21.7	38.3	50.8	73.0	160	45	20	90	272	
Average		22.2	43.0	54.1	76.6	163.6	47.6	19.3	92.6 ±1.19	280 ±3.11	
Normal soil heated to 70° C. for 8 hours, three times at 3 days interval.	1	24.2	45.7	60.2	88.7	198	56	15	111	372	Absent.
	2	25.7	46.1	62.0	79.5	190	52	12	108	352	
	3	26.8	42.0	58.0	72.7	188	51	12	106	345	
Average		25.6	44.6	60.0	80.3	192.0	53.0	13	108.3 ±0.98	356.3 ±5.38	

NOTE.—For results of unheated C-Soils and N-Soils see Table 4.

the heated N-soil (Plate 4), yet the leaves were normal green. They yield obtained from the heated soil, however, was much more than that from the unheated N-soil. In the heated N-soil an average of 113 ± 0.93 grams of grain was obtained as against 28.3 ±0.81 grams in the unheated N-soil (Table 6). In the same manner, the heated C-soil watered continuously with aqueous soil extract of heated C-soil produced very luxuriant growth of rice similar to those in the heated N-soil but the unheated C-soil produced poor plants (Plate 5). Again the characteristic yellowing of the rice leaves (*cadang-cadang* symptoms) was observed. From the above facts it can be deduced that the factors causing rice *cadang-cadang* are not transmissible and therefore rice *cadang-cadang* is not due to living organisms but most likely due to the lack of soil fertility.

EFFECT OF FERTILIZERS ADDED TO SOIL MEDIA

Rice cadang-cadang symptom absent.—The addition of certain combinations of inorganic fertilizers to the C-soil did not only augment the yield of the rice plants grown therein but also prevented the appearance of *cadang-cadang* (Plate 6). *Cadang-cadang* appeared on the rice plants planted in the unfertilized C-soil. The plants were poor, stunted, with narrow chlorotic leaves. It appears, therefore, that the cause of rice *cadang-cadang* is due to lack of soil fertility necessary for the normal growth of rice. In the same manner, the addition of inorganic fertilizers to N-soil also improved tremendously the productive capacity of the N-soil as shown by the luxuriant growth of the rice plants (Plate 7). The unfertilized cultures, although the growth of the plants was not as luxuriant, attained normal growth. But even at that the N-soil and more so the C-soil imperatively demand the application of fertilizers.

Lack of nitrogen in the soil.—The result shows that the C-soil is deficient in nitrogen (Table 7). There were enough phosphorous and potassium. The deficiency in nitrogen in the C-soil caused the appearance of what the Bicolanos call rice *cadang-cadang* (yellowing of leaves). These statements are based on the fact that when the combination of sulphate of ammonia and sulphate of potash; sulphate of ammonia, sulphate of potash and double superphosphate were added to the soil separately the rice plants grown therein did not show the symptom of rice *cadang-cadang*, but instead luxuriant growth and heavy yield in both straw and grain (Table 7). When sulphate of ammonia was

TABLE 6.—*Growth and yield data obtained from four rice plants grown in petroleum cans with cadang-cadang infested and non-infested soil. Cultures watered with aqueous soil extract*

Treatment of media	Culture number	Date of observation and criteria studied							Dry weight of grains	Dry weight of stalks	Presence or absence of cadang-cadang symptoms
		Feb. 4	Feb. 15	Feb. 25	March 7	June 9					
		Height	Height	Height	Height	Height	Number of bearing culms	Number of non-bearing culms			
		cms.	*cms.*	*cms.*	*cms.*	*cms.*			*gms.*	*gms.*	
C-soil, unheated. Plants watered with heated c-soil water extract.	1	21.0	45.5	57.2	63.0	140	12	2	26	39	Present.
	2	23.0	46.2	53.0	65.0	138	13	2	27	40	
	3	22.4	46.5	55.5	61.5	150	14	1	28	42	
Average		22.1	46.1	55.2	63.2	142	13	1.6	27 ±0.38	40.3 ±0.59	
C-soil, heated. Plants watered with heated c-soil water extract.	1	24.0	42.0	70.2	82.5	201	50	14	121	190	Absent.
	2	23.5	41.3	63.7	77.0	179	52	15	108	162	
	3	22.3	44.9	61.5	80.5	191	55	13	117	185	
Average		23.3	42.7	65.1	80.0	190.3	52.3	14	115.3 ±2.59	179 ±5.81	
N-soil, unheated. Plants watered with unheated c-soil water extract.	1	21.5	44.0	62.0	80.0	145	12	2	28	50	Absent.
	2	22.2	40.0	53.0	79.0	140	10	1	27	39	
	3	23.0	41.0	59.0	82.0	135	11	3	30	40	
Average		22.2	41.2	61.3	80.3	140	11	2	28.3 ±0.81	43 ±2.37	
N-soil, heated. Plants watered with unheated c-soil water extract.	1	22.0	45.0	67.0	90.0	201	53	12	111	170	Absent.
	2	24.0	46.0	70.0	85.0	195	50	15	116	185	
	3	23.0	45.0	68.0	90.0	198	55	12	112	175	
Average		23.0	45.3	68.3	88.3	198	52.6	13	113 ±0.93	176.6 ±2.97	

TABLE 7.—*Effect of commercial fertilizers added to cadang-cadang infested soil upon the growth and yield of four rice plants grown in petroleum cans*

Treatment of media	Culture number	Date of observation and criteria studied: Feb. 4	Feb. 15	Feb. 25	March 7	June 9			Dry weight of grains	Dry weight of stalks	Presence or absence of cadang-cadang symptom
		Height	Height	Height	Height	Height	Number of bearing culms	Number of non-bearing culms			
		cms.	*cms.*	*cms.*	*cms.*	*cms.*			*gms.*	*gms.*	
C-soil, unheated, plus sulphate of ammonia and double superphosphate.	1	23.0	51.1	66.5	86.0	175	37	2	63	120	Absent.
	2	24.0	48.5	66.0	92.0	180	38	1	62	115	
	3	25.0	50.0	69.0	94.0	185	32	1	59	102	
Average		24.0	49.8	67.2	90.6	180.0	35.6	1.3	61.3 ±0.81	112.3 ±2.25	
C-soil, unheated, plus sulphate of ammonia and sulphate of potash.	1	23.0	50.0	67.0	85.5	188	36	1	56	99	Absent.
	2	25.0	50.0	60.0	90.5	180	30	1	65	110	
	3	24.5	49.0	75.0	91.0	190	40	3	64	114	
Average		24.2	49.6	67.3	90.0	186.0	35.3	1.6	61.6 ±1.92	107.6 ±3.02	
C-soil, unheated plus sulphate of potash and double superphosphate.	1	23.4	41.2	52.1	61.5	135	12	2	23	42	Present.
	2	24.0	40.5	51.0	60.0	132	11	1	21	49	
	3	22.9	42.0	50.5	59.5	140	10	0	22	40	
Average		23.4	41.2	51.2	60.3	135.6	11	1	22 ±0.38	43.6 ±1.83	

C-soil, unheated plus sulphate of ammonia, sulphate of potash and double superphosphate.	1	24.5	42.0	69.0	86.5	170.0	36	2	66	121	
	2	25.0	48.5	70.7	87.0	185	39	2	60	115	
	3	27.0	49.0	75.0	80.0	180	35	3	61	119	Absent.
Average		25.5	46.5	71.6	87.5	178.3	36.6	2.3	62.3 ±1.25	118.3 ±1.19	
C-soil, unheated, plus sulphate of ammonia, sulphate of potash, double superphosphate and sulphate of magnesia.	1	24.0	41.0	70.0	85.0	170	36	2	66	120	
	2	23.5	49.0	65.0	79.0	180	29	0	59	105	Absent.
	3	25.0	50.0	72.0	85.0	190	40	3	60	115	
Average		24.2	46.6	69.0	83.0	180.0	35.0	1.6	61.6 ±1.47	113.3 ±2.97	
Average (control table 4)		21.6	38.9	47.5	52.6	126	10.2	2.6	20.4 ±0.51	45.0 ±2.27	Present.

TABLE 8.—*Effect of commercial fertilizers added to soil not infested with cadang-cadang upon the growth and yield of four rice plants grown in petroleum cans*

Treatment of media	Culture number	Date of observation and criteria studied							Dry weight of grains	Dry weight of stalks	Presence or absence of cadang-cadang symptom
		Feb. 4	Feb. 15	Feb. 25	March 7	June 9					
		Height	Height	Height	Height	Height	Number of bearing culms	Number of non-bearing culms			
		cms.	*cms.*	*cms.*	*cms.*	*cms.*			*gms.*	*gms.*	
N-soil, unheated, plus sulphate of ammonia and double superphosphate.	1	24.0	52.0	67.5	87.5	185.0	37	1	64	122	Absent.
	2	23.0	52.0	69.0	90.0	190.0	36	1	62	110	
	3	22.0	51.0	67.0	91.0	180.0	40	2	58	109	
Average		23.0	51.6	67.8	89.5	185.0	37.6	1.3	61.3 ±1.19	113.6 ±2.81	
N-soil, unheated, plus sulphate of ammonia and sulphate of potash.	1	23.0	52.0	68.5	91.2	190.0	37.0	1	63	120	Absent.
	2	24.0	50.0	69.0	95.0	189.0	35.0	2	60	118	
	3	24.0	50.0	70.0	89.0	192.0	40.0	2	59	101	
Average		23.6	50.6	69.2	91.7	190.3	37.3	2.6	60.6 ±0.81	113.0 ±4.06	
N-soil, unheated, plus sulphate of potash and double superphosphate.	1	23.0	48.0	55.0	87.0	140.0	12.0	0	26	40	Absent.
	2	25.0	50.0	54.0	90.0	135.0	14.0	1	29	51	
	3	23.0	47.0	59.0	85.0	150.0	11.0	0	28	45	
Average		23.6	48.3	56.0	87.3	141.6	12.3	.3	27.6 ±0.59	45.3 ±4.06	

N-soil, unheated, plus sulphate of ammonia, sulphate of potash and double superphosphate.	1	24.0	52.0	68.5	92.5	185.0	37.0	2	66	120	Absent.
	2	25.0	54.0	70.0	88.0	192.0	40.0	2	64	112	
	3	23.0	51.0	71.0	92.0	189.0	36.0	1	63	100	
Average		24.0	52.3	69.8	90.8	188.6	37.6	2.6	64.3 ±0.59	110.6 ±3.92	
N-soil, unheated, plus sulphate of ammonia, sulphate of potash, double superphosphate and sulphate of magnesia.	1	23.0	51.0	71.0	95.0	188.0	38.0	1	64	115	Absent.
	2	24.0	53.0	68.0	89.0	190.0	38.0	1	63	110	
	3	23.5	52.0	69.0	90.0	189.0	42.0	2	62	101	
Average		23.5	52.0	69.3	91.3	199.0	49.3	1.3	63.3 ±0.41	108.6 ±2.76	
Average (control table 4)		22.9	43.5	57.5	66.3	131.0	13	4.6	27.6 ±1.25	62.4 ±1.46	Absent

absent in the fertilizer combination of sulphate of potash and double superphosphate, the rice plants exhibited poor and chlorotic growth and low yield in both straw and grain (Table 7). The same trend of results was obtained with the N-soil which was fertilized (Table 8).

The addition of sulphate of magnesia to the three fertilizers used (N, P, K) in the C- and N-soils did not improve the yield of the rice plants both in straw and grain. Its absence in the combination in which sulphate of ammonia was a part entirely did away with the chlorotic condition of the leaves. This plant behavior points definitely to the presence in sufficient amounts in the soil of magnesia and that the deficiency in nitrogen in the soil is responsible for the retarded growth of the plants and the chlorotic condition of the leaves, which condition is called, in the Bicol provinces rice *cadang-cadang*.

SUMMARY AND CONCLUSIONS

Field observations and pot culture studies of the so-called rice *cadang-cadang* in the Bicol provinces were undertaken during the years 1935–1936 and 1937–1938.

Rice plants affected with *cadang-cadang* in rice paddies are generally dwarfed and with chlorotic leaves. The older leaves become yellow and only the inner younger leaves remain green. The roots of the plants are mostly brown except those which extend horizontally from the base and which are white and turgid.

Rice *cadang-cadang* was found in the Bicol provinces both in irrigated and unirrigated rice paddies where the surface soil is generally shallow and sandy, measuring about 4 to 5 inches deep. The subsoil is predominantly sandy to gravelly. The rice paddies were generally weedy and oftentimes the weeds became the dominant vegetation.

Rice plants planted in cans containing soil samples obtained from a *cadang-cadang* infested field in the Bicol provinces and watered regularly with water supplied by the Metropolitan Water District produced the symptoms of *cadang-cadang* observed in *cadang-cadang* rice paddies. The aqueous soil extract of soil infested with *cadang-cadang* when administered continuously to rice plants grown in a non-infested soil failed to produce the symptom of rice *cadang-cadang*. Rice grew luxuriantly in heated *cadang-cadang* soil. It appears probable that the heat treatment given to the media has changed, modified or ushered

in a condition whereby the nutritive substances in the soil became available to the rice plants. It may be inferred, therefore, that rice *cadang-cadang* is due to plant food deficiency in the soil.

Soil obtained from the Bicol provinces which is known to produce the symptom of rice *cadang-cadang* in the laboratory failed to cause rice *cadang-cadang* when commercial fertilizer containing sulphate of ammonia was added to it. Fertilizer studies conducted in can cultures point to the conclusion that the soil sample which causes rice *cadang-cadang* is deficient in nitrogen. Phosphorous and potassium in sufficient amounts are present in the soil. All other conditions necessary for growth being normal, the application of from 250 to 300 kilograms of sulphate of ammonia to a hectare of rice paddy will augment the yield materially. This finding is confirmed in field studies, the results of which will be published soon.

Heating *cadang-cadang* soil proves to be helpful and appropriate under laboratory conditions but its practicability in the field is doubted.

ACKNOWLEDGMENTS

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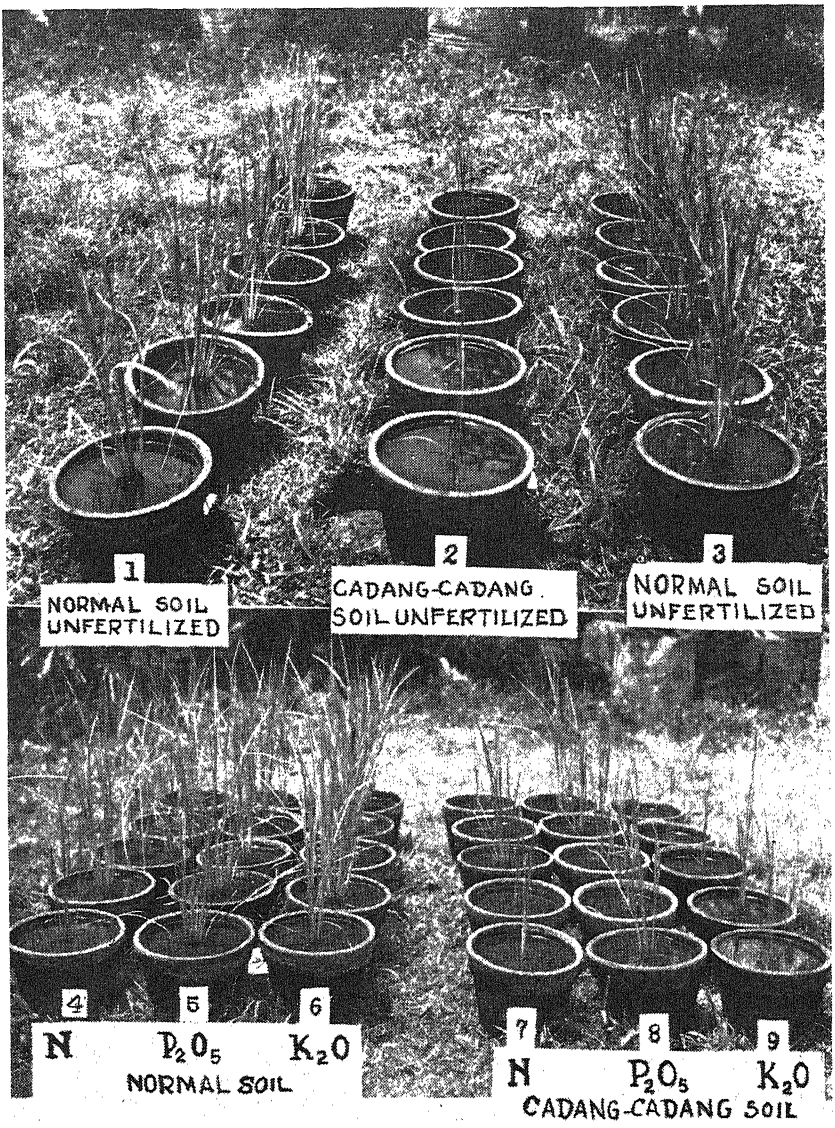
1
NORMAL SOIL
UNFERTILIZED
2
CADANG-CADANG
SOIL UNFERTILIZED
3
NORMAL SOIL
UNFERTILIZED
4
5
6
N
P_2O_5
K_2O
NORMAL SOIL
7
8
9
N
P_2O_5
K_2O
CADANG-CADANG SOIL

PLATE 1.

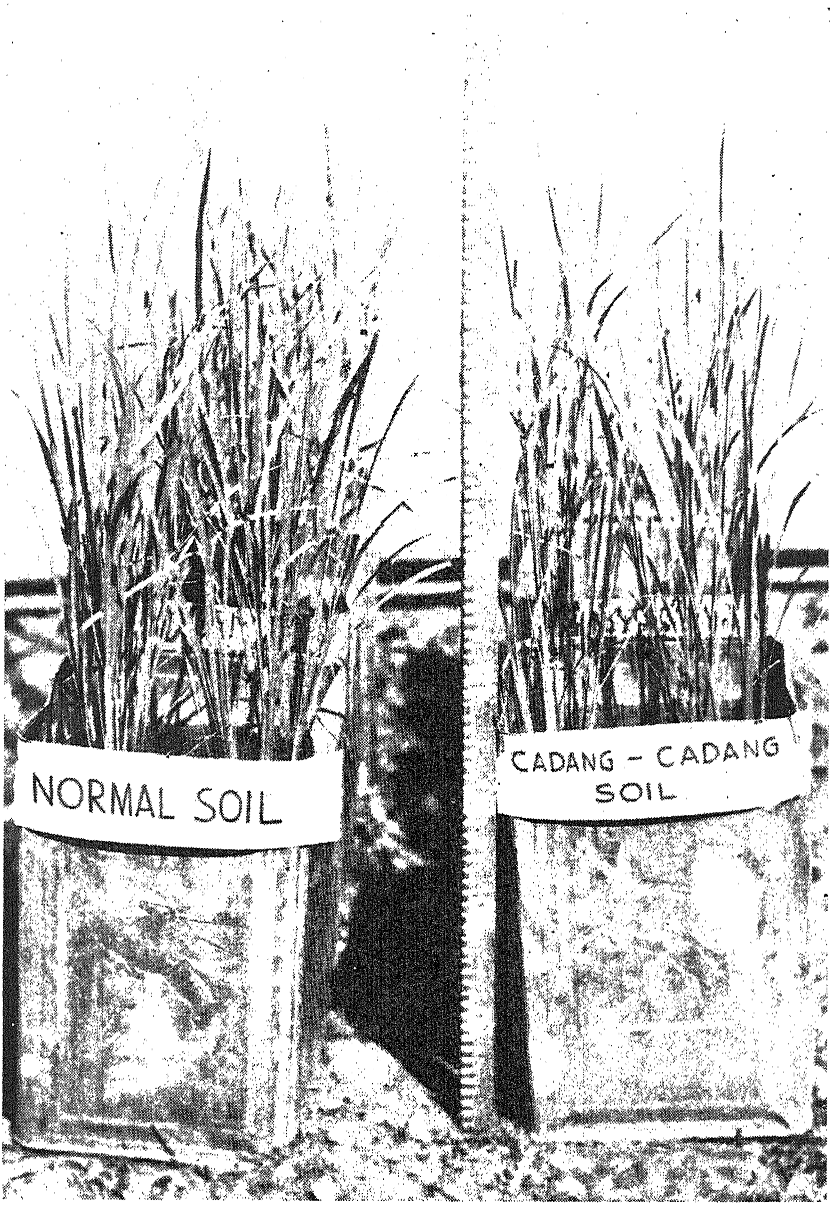

PLATE 2.

PLATE 3.

PLATE 4.


Not heated
CADANG-CADANG SOIL
Heated
CADANG-CADANG SOIL
Heated
NORMAL SOIL
Not Heated
NORMAL SOIL

PLATE 5.


CADANG - CADANG SOIL + NPKMg
CADANG - CADANG SOIL + NPK
CADANG - CADANG SOIL + NK
CADANG - CADANG SOIL + N P
CADANG - CADANG SOIL + PK
CADANG - CADANG SOIL (Control)

PLATE 6.

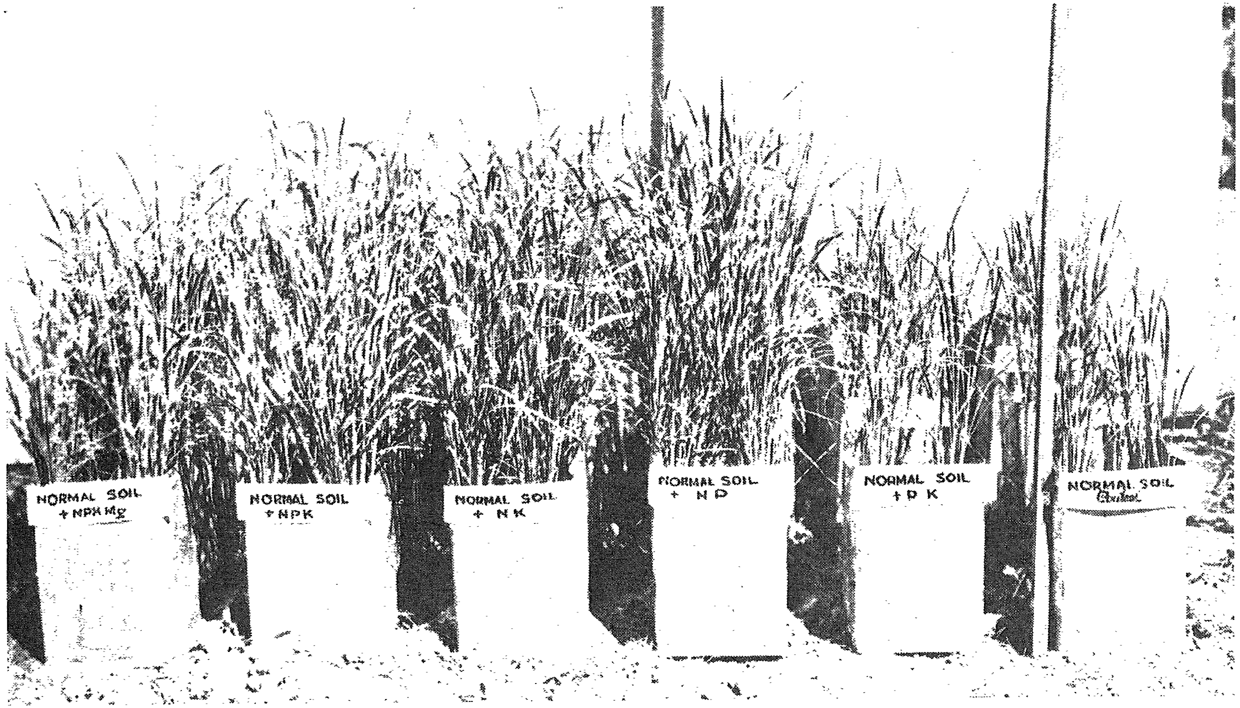
NORMAL SOIL
+ NPK Mg
NORMAL SOIL
+ NPK
NORMAL SOIL
+ N K
NORMAL SOIL
+ N P
NORMAL SOIL
+ P K
NORMAL SOIL

PLATE 7.

STUDIES ON THE MANUFACTURE OF GUAVA JELLY

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THREE PLATES

Growing wild almost everywhere in the Philippines, guava, although abounding during the rainy season, is consumed as food only to a limited extent while the rest goes to waste. One of the preparations of guava well known among Filipinos is guava jelly. It is marketed in flat, round tin cans of friction cover, $4\frac{1}{4}$ inches in diameter and $1\frac{1}{8}$ inches in height. Sold in Manila and in some large towns in the Philippines, this product is manufactured by some Chinese. Interisland steamship companies have contributed to a large extent to the popularity of this jelly, for it is served with cheese and bananas as dessert, practically everyday in almost all the interisland steamships.

The demand for guava jelly has become so great that it is seldom, if ever, absent in all grocery and sari-sari stores in Manila and in large towns of the Philippines. This so-called jelly, being a thick sticky syrup, certainly is a very inferior product, and should be labelled "syrup" rather than "jelly." It lacks the qualities of an excellent jelly, namely, to quiver when shaken, retain the shape of the container when removed from it, show the sides when cut with a knife, and retain the flavor of the fruit.

Although guava jelly is manufactured in this country in rather large quantities, the Philippines import(1) a considerable amount of it from other countries. The following table shows the yearly importation of jams, jellies, and marmalades.

TABLE 1.—*Yearly Philippine importation of jams, jellies, and marmalades.*[a]

Year	Quantity	Value
	Kilos	*Pesos*
1935	147,419	47,529
1936	138,233	50,883
1937 (first quarter)	33,203	13,501
Total	318,855	111,913

[a] Not published as a separate item prior to 1935.

The above data show that in a period of less than three years, the Philippine importation of jams, jellies, and marmalades was worth ₱111,913, a sum which conclusively indicates that these products command a good market in the Philippines.

For the purposes of enlightening the present guava jelly manufacturers in utilizing the excess guava, of increasing the farmers' income, and of encouraging ambitious capitalists to manufacture a better quality of jelly for local and for export trade, this study has been undertaken with the hope that in the future, the public will enjoy a real toothsome jelly.

REVIEW OF LITERATURE

Besides water, jelly has three important constituents, namely, pectin, acids, and sugar. Myers and Baker(2) in their work on fruit jellies, prepared an excellent jelly by combining in right proportions, pectin, acid, sugar, and distilled water. Fruit jelly, which is normally lacking in either pectin or acid, does not make a good jelly, but if supplied with any of these substances, a superior product results. From these facts, we can unmistakably infer that many failures in jelly making may be due mainly to the improper application of the above-mentioned substances.

The work of Haas and Hill(3) gives more light to the part played by pectin, acid, and sugar in jelly making. The claim of these authors that unripe fruits contain protopectose, the precursor of pectin and pectic acid, is now universally admitted. Fruits, upon ripening or on being boiled, according to them, transform protopectose into pectin, which together with acid, sugar, and water forms jelly. Again, they verified that prolonged boiling or treatment with an alkali further converts pectin into methyl alcohol and pectic acid, an insoluble substance, which is incapable of forming a jelly. This is one of the causes of the failures in jelly making.

The relations of protopectose, pectin and pectic acid are further illustrated in the following diagram:

Protopectose .... By boiling .... Pectin

By sodium hydroxide, cold

By pectinase brought about by rotting of the fruit, or by the action of alkali such as $Ba(OH)_2$ NaOH, and $Ca(OH)_2$.

Pectic acid and methyl alcohol

As important as pectin are the acids present in or supplied by the fruits. Goldwaithe(4) illustrated in the following table the effect of the presence of acids in juice on jellies.

TABLE 2.—*Effect of acids on the texture of finished jellies.*

Name of fruit	Acidity as H_2SO_4	Sugar to juice	Texture of jelly
	Per cent		
Crab apple	0.55	1:1	Excellent.
Do	0.00	1:1	Syrupy.
Do	0.27	1:1	Syrupy.
Grape	0.31	1:1	Excellent.
Do	0.00	1:1	Syrupy.

Table 2 proves the importance of the presence of the proper amount of acids in producing perfect jellies. As shown, the juice which formed excellent jelly produced a syrupy product when neutralized with sodium hydroxide.

Both pectin and acid are indispensable in fruit-jelly making. So is sugar. The application of the proper amount of sugar to make a perfect jelly is necessary as shown by Goldwaithe(4) in the following table.

TABLE 3.—*Effect of the proper amount of sugar on the texture of the finished jelly.*

Name of fruit	Acidity as H_2SO_4	Sugar to juice	Texture of jelly
	Per cent		
Crab apple	0.35	¼:1	Tough.
Do	0.35	½:1	Good.
Do	0.35	¾:1	Excellent.
Do	0.35	1:1	Too soft.
Grape	0.49	½:1	Tough.
Do	0.49	¾:1	Good.
Do	0.49	1:1	Excellent.

Table 3 shows that if the proper amount of sugar is added to the juice, an excellent jelly can be made. In the above illustration, crab apple, acidity 0.35 per cent mixed with equal amounts of sugar and juice, produced very soft jelly, whereas, the same amount with ¾ sugar to juice resulted in an excellent product. However, in the case of grapes, acidity 0.49 per cent, the same proportion of sugar to juice gave an excellent jelly.

COMMERCIAL POSSIBILITIES OF GUAVA-JELLY MAKING

The present and future importance of guava-jelly making can be ascertained from the point of view of cost and demand. As for the first consideration, the chances are very favorable, for the price of guava fruit is very cheap and at the same time the supply is unlimited—the only handicap being the lack of cultivated farms, where buying can be concentrated. Other materials needed, like sugar and acid–producing fruits, abound in the Islands. Labor can be secured at comparatively low cost so that under the guidance of an expert, it can be expected to produce good results. In short, so far as the cost of production is concerned, the prospect is bright (see Table 4).

Local and foreign markets are our next consideration. That the local market for manufactured confections is well established is verified in Table 1, which shows that our import of the same amounts to quite a considerable sum of money. With improved quality of jelly, this local demand can be further expanded by educating the people on the food values of native manufactured fruit products, and by making them appreciate and patronize such commodities. The same is true of the demand abroad. All that a manufacturer has to do is to keep up with the standard quality of the foreign made product. The novelty and flavor of the locally made product will enable him to compete favorably with foreign manufacturers. With systematic advertising abroad, guava jelly may prove an indispensable delicacy in foreign homes.

The following table shows the commercial possibility of manufacturing guava jelly. The calculations of cost and selling prices are based on data from a factory that has an output of jelly made from six baskets or "kaings" of guavas.

TABLE 4.—*Cost of production and selling price of guava jelly.*

A. *Cost of production:*	
Guava fruit (1 basket or "kaing" of 23 kilos)	₱0.80
Sugar (second class), ₱0.08 × 21	1.68
Containers (10-oz. cap.), ₱0.09 × 86	7.74
Sources of acid:	
Either tamarind, calamansi juice, santol, or citric acid	0.37
Labels, ₱0.01 × 86	0.86
Fuel (coal)	1.00

Labor:	
Two one-peso laborers	₱0.34
One technical helper	0.34
Miscellaneous	0.20
Overhead (5 per cent of the sum of the above item)	0.66
Total	₱14.99
B. *Selling price* (wholesale) 25 × 86	21.50
Net profit	₱6.51

METHODS EMPLOYED IN JELLY-MAKING

Extractions of guavas with different proportions of water.—Guava, which belongs to a group of practically non-juicy fruits, needs water to extract the pectin, acid, and flavor for jelly making. Thus the determination of the amount of water to be used is the first consideration, for the presence of the right amount determines the grade and quality of the jelly. The following proportions were used in the extractions:

1. Equal amount of guava and water.
2. Utilization of the first and second extracts of the above proportion.
3. One part guava and two parts water.
4. Two parts guava and three parts water.

The fruit is boiled for thirty minutes in any of the above mentioned proportions. Then the juice is strained and with sugar and the amount of acids needed, jellies are made at a jellying point of 108°C.

Utilization of tamarind fruit and calamansi as sources of acids.—In the absence of citric acid, green tamarind fruit was utilized, the percentages of which ranged from 10 to 30 per cent.

The guava fruits were separately boiled for thirty minutes with 10, 15, 20, 25, and 30 per cent green tamarind. The strained juices were separately labelled according to the percentage of tamarind present.

Fresh *calamansi* juice was also used in the absence of either citric acid or tamarind with gratifying results. The amounts used ranged from 3 to 27 tablespoonfuls (1 tablespoonful of *calamansi* juice weighs 12 grams) per kilo of guava juice.

Determination of total acidity.—In order to determine the total acidity of the juice, 10 cc. samples were taken and titrated with one-tenth normal sodium hydroxide solution.

Preparation of jelly.—A standard method of jelly making was followed in all the experiments. It is described as follows:

To one part (by weight) of guava juice one-half part of sugar was added. To this mixture acid in the form of either citric acid or *calamansi* juice was also added to adjust the acidity. Acids present in guava juice are not sufficient to form a satisfactory jelly. The mixture was heated to the boiling point, then strained, and heated again until the jellying point of 108°C. was reached. The finished jelly was transferred in clean dry jelly jars.

RESULTS AND DISCUSSION

TABLE 5.—*Effect of the proportion of guava to water on the texture and color of the jelly.*

Guava to water	Acidity as acetic acid	Citric acid added	Texture of jelly	Color of jelly
Parts	*Per cent*	*Grams*		
1:1	0.34	None	Syrupy	Light amber.
1:1	0.34	2	Excellent	Do.
1:1 (1st and 2nd extracts)	0.30	None	Syrupy	Do.
1:1 (1st and 2nd extracts)	0.30	2	Good	Do.
1:1 (1st and 2nd extracts)	0.30	4	Excellent	Do.
1:2	0.27	None	Syrupy	Lighter amber.
1:2	0.27	2	Good	Do.
1:2	0.27	4	Excellent	Do.
2:3	0.28	None	Syrupy	Do.
2:3	0.28	2	Good	Do.
2:3	0.28	4	Excellent	Do.

Table 5 indicates that in the proportions 1:1, 1:2, and 2:3 (guava to water) guava alone cannot produce satisfactory jelly, but with the addition of certain amounts of citric acid, any proportion up to 1:2 produces perfect jellies. It has also been proved that guavas contain much pectin so that even the proportion 1:2, with four grams of citric acid, produces a good quality of jelly. Guava juice, therefore, diluted with water cannot produce excellent jelly unless acid is added to it.

Utilization of calamansi and tamarind.—For the purpose of utilizing some indigenous fruits in supplying acidity to guavas, *calamansi* and green tamarind were separately used. Different amounts of *calamansi* juice were added in order to determine the limits at which a good jelly could be prepared.

TABLE 6.—*Effect of the different amounts of calamansi juice on the texture and color of the jelly.*

Juice to sugar	Calamansi juice added	Acidity as acetic acid	Texture of jelly	Color of jelly
Filos	*Tablespoons* [a]	*Per cent*		
1:½	None	0.31	Syrup	Lighter amber.
1:½	3	0.43	Good	Do.
1:½	6	0.53	Excellent	Do.
1:½	9	0.65	do	Do.
1:½	12	0.79	do	Light amber.
1:½	15	0.83	do	Do.
1:½	18	1.00	do	Do.
1:½	21	1.19	do	Do.
1:½	24	1.30	do	Sl. dark amber.
1:½	27	1.43	do	Do.

[a] One tablespoon of *calamansi* juice equals 12 grams, approximately 12 cc.

Table 6 again proves that guavas alone cannot produce a good quality of jelly as they lack acid. However, an excellent guava jelly can be prepared with *calamansi* juice ranging from 6 to 27 tablespoonfuls or an average of 3 to 14 *calamansi* fruits per kilo of guava juice. It is distinctly shown that the intensity in color(5) and transparency(6) of the jelly increases as the amount of *calamansi* juice is correspondingly increased.

TABLE 7.—*Effect of different amounts of green tamarind on the texture and color of the jelly.*

Tamarind in guava	Juice to sugar	Acidity as acetic acid	Texture of jelly	Color of jelly
Per cent	*Kilos*	*Per cent*		
10	1:½	0.47	Good but turns sugary	Lighter amber.
15	1:½	0.49	Excellent	Do.
20	1:½	0.55	do	Do.
25	1:½	0.60	do	Deep amber.
30	1:½	0.69	do	Do.

As shown in the above experiment, tamarind, another sour fruit serves satisfactorily in supplying acidity to guavas. In the experiment, different percentages of tamarind were used during the preparation of the guava fruit extraction with water. Jellies made with acids from tamarind, besides being excellent, contain more food value than those to which citric acid has been added.

It can be seen that jellies made with from 15 to 30 per cent tamarind are all excellent from the standpoint of color, transparency, and texture. It was noted that as the amount of tamarind was increased, the intensity in color (5) and transparency (6) correspondingly increased. It is, however, recommended that for sweet jellies, 15 to 20 per cent tamarind should be used; for slightly sour ones, 25 to 30 per cent.

The effect of different kinds of containers on the color of the finished jelly.—In this experiment three kinds of containers were used, namely, copper (tacho), enameled and aluminum. Different kinds of juices (obtained by preparing the extraction from the fruit with different proportions of water) were employed for the purpose of determining which would produce better results; the first extract, or the first and second extracts combined.

TABLE 8.—*Effect of copper, enameled, and aluminum containers on the color of the jelly.*

Acidity as acetic	Citric acid added	Kind of juice	Types of containers	Color of jelly
Per cent	*Grams*			
0.33	2	1st extract	Aluminum	Amber.
0.28	4	1st and 2nd extracts	Aluminum	Light amber.
0.33	2	1st extract	Copper	Amber.
0.28	4	1st and 2nd extracts	Copper	Light amber.
0.33	2	1st extract	Enameled	Amber.
0.28	4	1st and 2nd extracts	Enameled	Light amber.

Table 8 shows that the jellies prepared with the first extract in aluminum, copper, and enameled containers were all amber and of the same intensity. On the other hand, those with the first and second extracts combined were all light amber. We can safely infer that the kind of container does not affect the color of the jelly, but that the kind of juice employed does affect it.

The effect of sugar, high and low grades on the color, texture, and transparency of the jelly.—In this experiment, expensive sugars, such as suchar, and snowflakes, together with second class washed sugar were used in order to determine their effects on the color, texture, and transparency of the jelly. Citric, tartaric, and sulphuric acids were also used.

TABLE 9.—*Color of guava jelly made with different kinds of sugar and acids.*

Kinds of acids	Kinds of sugar	Acidity as acetic acid	Acid added	Color of jelly
		Per cent	*Grams*	
Citric	Washed	0.23	4	Light amber.
Do	Suchar	0.23	4	Do.
Do	Snowflakes	0.23	4	Do.
Tartaric	Washed	0.23	4	Do.
Do	Suchar	0.23	4	Do.
Do	Snowflakes	0.23	4	Do.
Sulphuric	Washed	0.23	4	Do.

Table 9 shows that jellies made with washed, suchar, and snowflakes sugars were all of the same color (light amber) and transparency regardless of the acid used, with the exception of sulphuric acid, which hydrolyzed the pectin and caramelized the sugar, completely spoiling the product and making it unfit for human consumption. The kind of useful acids and sugar have, therefore, no material effect on the color and quality of the jelly. However, especially in commercial scale production, tartaric acid [b] and washed sugar are highly recommended for guava-jelly making, for they are comparatively cheaper than citric acid, suchar, and snowflakes sugars.

TABLE 10.—*Relative color intensity of guava jelly depending upon the kinds of brown sugar used, utilizing 15 per cent tamarind as a source of acids.*

Juice to sugar	Kinds of sugar [c]	Acidity as acetic	Texture of jelly	Color of jelly
Kilos		*Per cent*		
1:½	Washed No. 2	0.46	Excellent	Light amber.
1:½	Brown No 3	0.46	Good	Dark brown.
1:½	Brown No. 4	0.46	Fair	Darker brown.

[c] Washed sugar No. 2 is light brown; No. 3 is brown; and No. 4 is dark brown.

As shown in the above table, the jellies made with brown sugar Nos. 3 and 4 were inferior in color and transparency to those made with washed sugar. The latter then, in spite of cost, should be utilized if the manufacturers intend to produce an excellent guava jelly.

[b] Tartaric acid costs ₱1.40 per kilo; citric acid, ₱1.75.

The utilization of peeled guavas.—For peeling the guavas, 3 per cent sodium hydroxide was used. This process of peeling takes very much shorter time than with paring knife. The peeled guavas, after having been washed several times with running tap water to remove completely the alkali, were made into jelly in the same way as the unpeeled guavas. The very attractive color and transparency of the jellies which resulted from the peeled guavas compensated for the labor employed and the extra material used.

The effect of heat on the color of the jelly.—Inasmuch as the degree of heat needed, the time consumed in cooking the jelly, and size of the batch used are important factors in the commercial production of guava jelly, without endangering the quality of the finished product, experiments utilizing different degrees of heat and sizes of batches were undertaken. For a high degree of heat, the gas stove in the kitchen of the Plant Utilization Division, Bureau of Plant Industry, was employed.

TABLE 11.—*Effect of very low, moderate, and very strong heat on the color of the finished jelly.*

Size of batch	Acidity as acetic acid	Citric acid added	Heat	Time		Color of jelly
Kilos	*Per cent*	*Grams*		*Min.*	*Sec.*	
2	0.27	8	Moderate	32		Light amber.
2	0.27	8	Very strong	15	30	Deep amber.
2	0.27	8	Very low	50		Deeper amber.
5	0.27	20	Very strong	44	30	Deeper amber.

The above table shows that in order to obtain a jelly of light amber, a very attractive color, moderate heat with a two-kilo batch is indispensable. Very intense heat, on the other hand, results in the slight caramelization of the sugar, a condition which accounts for the slightly darker color of the jelly. The same size of batch, two-kilo juice, cooked over very low fire gives a slightly deeper amber. A five-kilo juice cooked over very strong fire produces a slightly deeper colored jelly, which is still attractive. The latter experiment is suggested for commercial scale production, for the time consumed is only 44½ minutes, a period short enough to enable the factory to make many batches during the day.

The effect of sulphuric acid on the color and grade of jelly.—The application of sulphuric acid varied from one to four grams per kilo of guava juice. In this experiment different amounts

of sulphuric acid were used instead of other kinds of acids, such as citric and tartaric acids, or acids from either *calamansi* or tamarind, in order to supply the guava juice with acid.

TABLE 12.—*Color of the jelly and time consumed when sulphuric acid was added.*

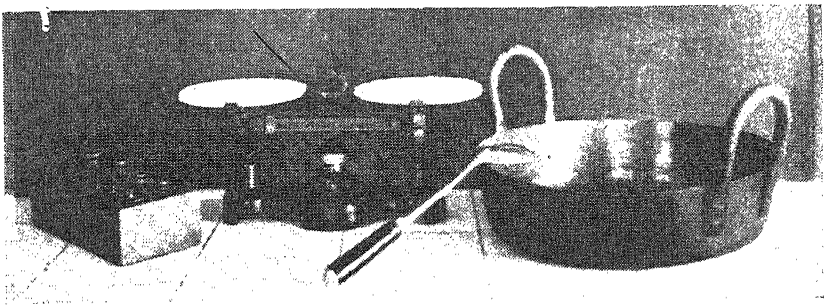
Size of batches	Acidity as acetic acid	Sulphuric acid added	Time		Texture of jelly	Color of jelly
Kilos	*Per cent*	*Grams*	*Min.*	*Sec.*		
1	0.27	1	13	10	Soft	Too light.
1	0.27	2	18	30	Excellent	Amber.
1	0.27	3	20	50	Good	Brown.
1	0.27	4	21	30	Syrupy	Very dark (caramelized).

Table 12 shows that the color of the finished product depends upon the amount of sulphuric acid used; that is, the lesser the acid, the lighter the color of the jelly. Jellies made with two grams of sulphuric acid are the best in texture, transparency, and color, but those with four grams are very dark and syrupy. This fact is due mainly to the partial hydrolysis of the pectin with subsequent caramelization of the sugar which in turn, causes the dark coloration.

SUMMARY AND CONCLUSIONS

1. Perfect jellies can be made from guavas, even in the proportion of 1:2 of fruit to water, using four grams of either citric or tartaric acid, or *calamansi* juice, or green tamarind.
2. The use of the proper amounts of pectin, acid, and sugar is essential in the manufacture of excellent guava jelly.
3. In the absence of either tartaric or citric acid, both tamarind and *calamansi* juice serve as subtitutes in the production of a perfect guava jelly.
4. Copper, enameled, and aluminum containers when used in cooking the jelly do not materially affect the color, transparency, and texture of the finished product.
5. First-class sugar has no material advantage over washed sugar from the point of view of color, transparency, and texture.
6. Peeled guavas produce lighter colored jelly than the unpeeled ones.
7. Very strong or very low fire tend to produce a very much darker colored product than that with moderate heat. The bigger the size of a batch, regardless of the degree of heat used, the darker the color of the jelly.

PLATE 1.



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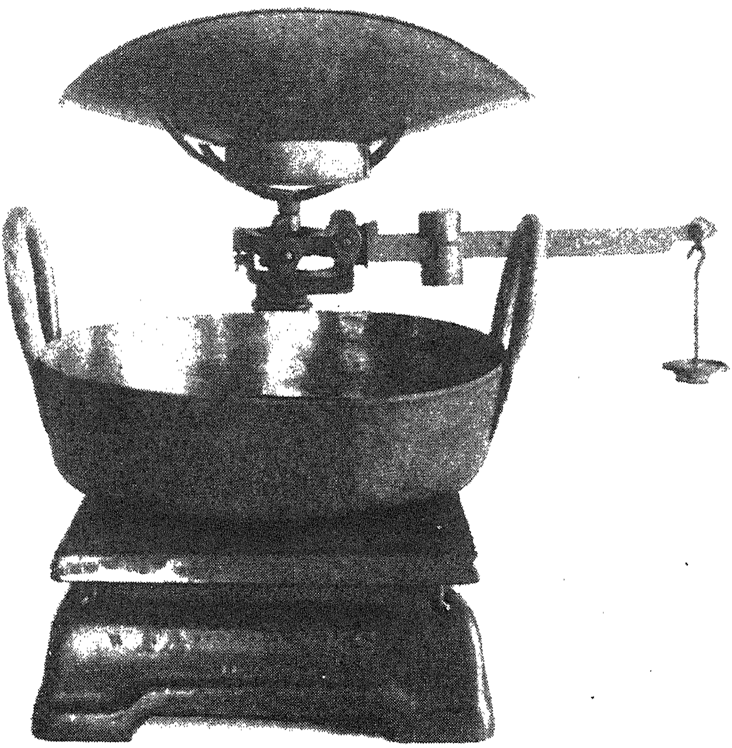

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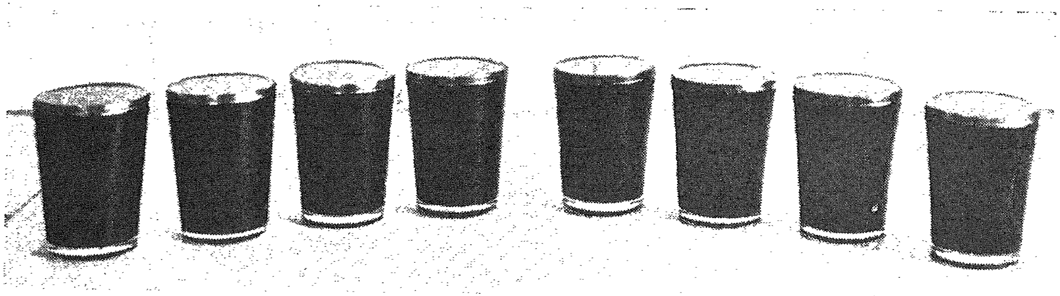
PLATE 2.



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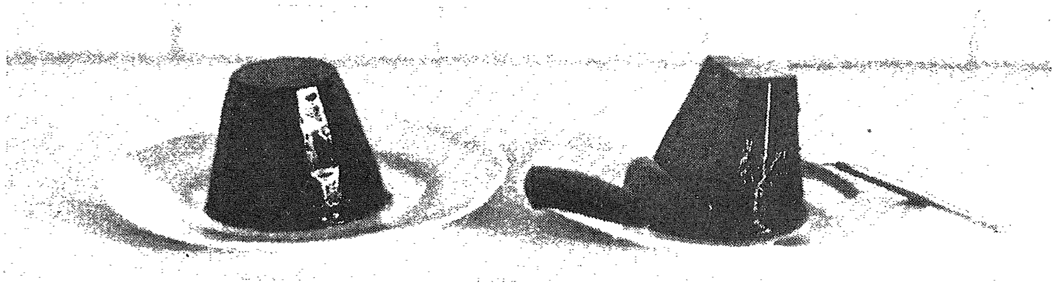

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PLATE 3.

NOTES ON THE ROTENONE CONTENT OF CEBU DERRIS

By JUAN M. EJERCITO
Of the Horticulture Section, Bureau of Plant Industry

TWO PLATES

Until the end of the year 1937, Cebu led in the area planted to derris in the Philippines. No less than 600 hectares were under cultivation, of which the towns of Barili, Minglanilla, Toledo, and Talisay led in the order of their enumeration. Talisay and Minglanilla were the first towns to have extensive derris fields. (See Plates 1 and 2.) Commercial consignments of derris roots from Cebu have shown a toxic content which is quite acceptable in the market. For this reason, Cebu became one of the principal sources of planting materials (stem cuttings) for the different provinces. Most of the orders were placed through the Bureau of Plant Industry, Manila or through its branch office in Cebu. However, in some cases the materials were purchased direct from some private planters in Cebu. For the benefit, therefore, of those who bought planting materials of Cebu derris, and those would-be derris planters, this paper has been prepared with the aim in view of showing the rotenone content of Cebu derris planted in different parts of the Philippines.

MATERIALS

The derris referred to in this paper is supposed to be a strain of *Derris elliptica* (Roxb.) Benth. It is called "Pilipogon" in Cebu. Most of the materials supplied to fill up the orders made through the Bureau of Plant Industry were of this strain. Another strain which is equally as good as "Pilipogon" is "Ikog-ilaga." Both are widely planted in Cebu. They resemble very much each other in their mode of growth, number, size and shape of leaflets except in the shape of the vines and roots. "Ikog-ilaga" can be identified by its roots and stems which taper more abruptly towards the tip than those of "Pilipogon." This abrupt tapering seems to be due to its shorter internodes.

DISTRIBUTION OF MATERIALS

In Table 1 are shown derris planters in different parts of the Philippines, and the extent of their plantings as judged by the number of cuttings ordered.

TABLE 1.—*Planters of Cebu derris in various parts of the Philippines*

Planter and address of farm	Quantity bought	Date bought
Victor de los Reyes, Nampicuan, Cuyapo, Nueva Ecija	1,000	July, 1935.
Calamba Sugar Estate, Canlubang, Laguna	20,000	August, 1935.
C. Sandiko, balas, Mexico, Pampanga	2,000	October, 1935.
A. Escudero, Tabasin, Tiaong, Tayabas	2,000	November, 1935.
Philippine Milling Company, San Jose, Mindoro	240,000	December, 1935.
L. Espejo, Umingan, Pangasinan	10,000	June, 1936.
P. San Agustin, Concepcion, Sariaya, Tayabas	5,500	July, 1936.
Granja Sugar Cane Expt. Station, La Carlota, Occ. Negros	50,000	September, 1936.
D. Sy Cip, Dumaguete, Oriental Negros	4,000	Do.
Jose Dizon, Calasiao, Pangasinan	200	Do.
R. Tumbokon, Agbago, Ibajay, Capiz	10,000	October, 1936.
M. G. Blardony, Balara, Mariquina, Rizal	1,650	April, 1937.
M. G. Blardony, Magallanes, Cavite	48,000	May, 1937.
G. Pondoc, Sta. Ana, Davao	Bought direct from Cebu.	

RESULTS

Table 2 presents the results of analyses of "Pilipogon" derris as grown in different sections of the Philippines outside of Cebu Province while Table 3 shows the analysis of the same derris variety as grown in Cebu.

TABLE 2.—*Results of analyses of roots of Pilipogon variety in different places (moisture free basis)*

Place of farm	Type of climate	Kind of soil	Age harvested	Ether extract	Rotenone
			Months	*Per cent*	*Per cent*
San Jose, Mindoro	First type [a]	Sandy loam	21		[d] 8–10
Do	do	do	25		[d] 4.50
Calamba, Laguna	do	Mixture of loam and adobe.	16	10.68	5.00
Magallanes, Cavite	do	Clay loam	10½		3.87
Balara, Mariquina, Rizal	do	Red clay loam	13	16.07	[e] 4.69
Nampicuan, Nueva Ecija	do	Clay loam	24		2.65
Balas, Mexico, Pampanga	do	Sandy loam	12	11.44	3.54
Umingan, Pangasinan	do	Silt loam	24	10.00	5.35
Calasiao, Pangasinan	do	Sandy loam	21	28.30	9.45
La Carlota, Occ. Negros	do	do	18	37.91	4.18
Agbago, Ibajay, Capiz	Intermediate A-type [b]	do	24	3.56	1.76
Tabasin, Tiaong, Tayabas.	do	Clay sandy loam	24	31.12	8.39
Dumaguete, Or. Negros	do	do	24	40.34	5.13
Concepcion, Sariaya, Tayabas.	Intermediate B-type [c]	Black silt loam	18	21.10	[f] 8.05
Sta. Ana, Davao	Intermediate B-type [c]	Sandy loam	24	34.03	6.59

[a] Two pronounced seasons: dry in winter and spring (December–May), wet in summer and autumn (June–November).

[b] No very pronounced maximum rain period; with a short dry season lasting only from one to three months.

[c] No very pronounced maximum rain period and no dry season.

[d] Analyzed by Botica Boie Laboratory.

[e] Analyzed by Warner Barnes Laboratory.

[f] Analyzed by College of Agriculture, U. P.

The others not indicated were analyzed by the Chemistry Section, Bureau of Plant Industry.

TABLE 3.—*Results of analysis of derris roots of Pilipogon variety as grown in Cebu (moisture free basis)*

Place of farm	Type of climate	Kind of soil	Age harvested	Ether extract	Rotenone
			Months	*Per cent*	*Per cent*
Tabunok, Talisay	Intermediate A-type[b]	Calcareous	12	17.67	4.90
Do	do	do	24	11.90	3.50
Bulakao, Talisay	do	do	24	20.17	5.74
Do	do	do	24	35.35	4.63
Talisay	do	do	24	37.70	4.46
Tabunok, Talisay	do	do	24	20.10	2.49
Do	do	do	18	24.46	8.04
Do	do	do	48	19.64	6.03
Talibon	do	do	24	------	[c]8.26
Danao	do	do	24	------	[c]3.33
Medellin	do	do	24	------	[c]2.18

[b] No very pronounced maximum rain period with a short dry season lasting only from one to three months.

[c] Analyzed by the Bureau of Science. Ether extract is not available.

TABLE 4.—*Lime content of soil samples and percentage of rotenone content of derris grown in different places*

Places	Lime (CaO)	Ether extract	Rotenone
	Per cent.	*Per cent.*	*Per cent.*
Bulakao, Talisay, Cebu	9.38	24.46	8.04
Tabunok, Talisay, Cebu	3.16	19.64	6.03
Marigondon, Opon, Cebu	1.66	21.80	4.87
Carmen, Bohol	0.138	18.90	1.61

DISCUSSION OF RESULTS

As shown in Tables 2 and 3 the rotenone content of Cebu derris (Pilipogon variety) as grown in different places varied considerably. In Cebu Province itself, the native habitat of the variety under consideration, the rotenone content varied from 2.18 per cent to 8.26 per cent. Of the different places where samples for analysis were taken, 64 per cent showed commercial rotenone content while 36 per cent were below commercial grade.[1] (Table 3). Likewise, the samples from different places outside of Cebu showed the same wide variation in rotenone content. For example, in the sample from Agbago, Ibajay, Capiz, the rotenone content was as low as 1.76 per cent while that from Calasiao, Pangasinan gave an exceptionally high rotenone content of 9.45 per cent (Table 2). Seventy-three per cent of the localities outside of Cebu which grew Cebu derris produced roots having commercial rotenone content and the remaining 27 per cent yielded low-rotenone producing roots (Table 2).

These results are very significant; they show that Cebu derris may not be of only one variety or strain but of different strains of divergent rotenone content, or that the rotenone content of the derris plant may be affected by soil conditions and age at harvest. With respect to the existence of different strains, this is very possible because prior to the cultivation of derris which is very recent, its propagation was left to nature, and in all likelihood this was by sexual means or by seeds. If the variation in rotenone content is due to the existence of different strains, this is a healthy sign as it will eventually lead to the isolation of strains of high rotenone content. Already, work along this line is in progress and its results will be published in the near future.

It is also equally possible that the soil and its composition are factors greatly affecting the rotenone content of derris. Preliminary results obtained from the analysis of soil samples from different derris fields in Cebu and Bohol seem to indicate that soils having a considerable amount of lime have a decidedly higher rotenone content than those with less lime. (See Table 4.) These results will be verified further.

Likewise, the age at harvest time may affect the rotenone content of derris. In Malaya, it has been found out that the optimum age for harvesting is 25 months, considering of course the yield of roots and the total amount of ether extract.[1] Similar study is being undertaken by the Bureau of Plant Industry.

SUMMARY

1. The rotenone content of Cebu derris (Pilipogon variety) has been studied.
2. There exists a wide variation in rotenone content of the different samples analyzed.
3. Sixty-four per cent of the samples taken from the different localities in Cebu were commercial and the remainder were noncommercial. Of those grown in the different provinces outside of Cebu, 73 per cent were commercial.
4. Variations in rotenone content may be attributed to difference in strains, age at harvesting, and soil conditions.
5. Isolation and multiplication of only the highest yielding strains or variety should be practiced to produce a standard variety.

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[1] GEORGI, V. D. C. and A. E. CURTLER. The periodic harvesting of tuba root. Malayan Agr. Jour. 17 (1929) 326-334.

ACKNOWLEDGMENT

The writer wishes to acknowledge the assistance rendered by the Chemistry Laboratory of the Bureau of Plant Industry in the analysis of most of the derris samples; by our coöperators, the Philippine Milling Company, San Jose, Mindoro; Messrs. M. G. Blardony and P. San Agustin who kindly furnished him with the results of analysis and other data pertaining to the derris they bought from this Bureau; Agricultural Supervisors Antonio Derecho of Cebu, Cebu, Jose Mendoza of Dagupan, Pangasinan, Primo Honrado of Capiz, Capiz, Assistant Agricultural Supervisor Floro B. Flores of Sta. Cruz, Laguna, and Mr. Fernando G. Galang, Municipal Agricultural Inspector of San Fernando, Pampanga in sending samples and gathering data on Cebu derris grown in their respective localities. The writer is also indebted to Mr. P. A. Rodrigo of the Horticulture Section, for valuable suggestions offered in the course of preparation of the manuscript.

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ILLUSTRATIONS

PLATE 1

A partial view of an extensive derris plantation (two years old) in the mountains of Lagtang, Tabunok, Talisay, Cebu. Note the thick growth that covers entirely the ground.

PLATE 2

A view of a commercial derris plantation in Minglanilla, Cebu. Note the interplantings of corn and banana.

PLATE 1.

PLATE 2.

CORN CULTURE IN THE PHILIPPINES

(Farmers' Circular No. 24 (Revised)

THREE PLATES

Corn is the second grain crop of the Philippines in importance. In the provinces of Cebu, Bohol, Siquijor, Cagayan, Isabela, and Abra, it leads rice as a staple food but in other places in the Philippines it is second to rice. The ten principal corn growing provinces in the order of their importance are Cebu, Leyte, Negros Oriental, Negros Occidental, Iloilo, Cagayan, Isabela, Batangas, Pangasinan and Occidental Misamis. Corn is so well adapted to the climatic and soil conditions in the Philippines that its production can be increased many times:

Cultivated area and production

Item	1936	1937
Area cultivated........Hectares..	685,010	659,400
Production........Cavans..	6 370 690	7,678 080
Average yield per hectare........Cavans..	9.30	11.64
Value of production........	₱15.713.850	₱17,983 350

Philippine importation of corn

Year	Quantity	Value
	Kg.	
1931	6,372.941	₱177,090
1932	137.786	180,348
1933	7,154,981	207,681
1934	160,687	39,963
1935	222.830	61,715
1936	208,929	53,757
1937	181,401	47.089

Types of corn.—There are four types of corn under cultivation which are of commercial importance. They are the flint, dent, sweet and pop corn. The other types, such as soft corn and pod corn are of no commercial importance.

Flint corn is characterized by a flinty or hard endosperm. It is of various colors, the most common of which are yellow and white. Flint corn is the common type being raised in the

Philippines. The Cebu white flint is better than any of the other varieties of flint corn because good quality *bugas* corn (corn rice) could be obtained from it. The most important varieties of the flint type are the Cebu white, Bohol white, Cagayan white, Calipus white, Moro white and Calamba yellow.

Dent corn, as distinguished from the flint corn, has a horny endosperm at the sides and a starchy endosperm in the middle toward the top. The shrinkage of the starch at the crown on drying leaves the kernel dented. Dent corn is very susceptible to weevils. Hence the reluctance of farmers to plant it. Honduras Nos. 1 and 2 which were recently introduced into the Philippines show signs of promise while the American Mestizo white semi-dent, also recently introduced, is now under extensive cultivation in Lanao, Mindanao.

Sweet corn is characterized by the wrinkled condition of the kernel caused by drying. It is raised on a small scale in many parts of the Philippines. Surecropper and Honey June, recently introduced from the United States are now successfully grown in this country.

Pop corn is characterized by an excessive amount of corneous endosperm, and the small size of the kernel and the ear. The popping is caused by an expansion of the moisture inside the kernel upon heating. One type of pop corn is the rice pop corn which has pointed kernels. The other type is the pearl pop corn which is very similar to small flinty corn. The Golden Queen and the Yellow pop corn are two other varieties grown in the Philippines. Small areas throughout the country are planted to pop corn just to meet local demand.

Glutinous corn, as its name indicates is more or less gluey when cooked. This variety is soft and is used much for green corn. It is in great demand in the market. The plants are of medium height and begin to tassel in 45 to 50 days after planting. The crop matures in 90 to 110 days. The ear measures 4 to 5 cm. in diameter and from 10 to 16 cm. long. It tapers gradually towards the tip. It is fairly distributed in the Ilocos provinces, Cagayan Valley, Batangas and in some parts of the Philippines. The average yield is about 15 cavans per hectare.

Seed corn.—Seed corn should be selected from standing stalks in the field. It should be well-formed, mature and from strong, vigorous and healthy plants. Plants which topple over, and have tendency to sucker as well as plants showing disease symptoms should not be chosen. Diseased plants are likely to produce

diseased seeds which, when used as seeds, may produce stunted and unproductive plants. The selection of seed corn should be done during the ripening period of the crop.

Ears for seed should be tightly covered with husks two to three inches beyond the tip and should be borne on a strong, healthy shank forming a medium angle with the stalk. A good ear for seed is one which is symmetrically developed, cylindrical in form, with straight and full rows of kernels from the butt to the tip. The kernels should be uniform, deep and rectangular in shape. The grains should be bright in color, plump and with well developed germs. Low-borne ears usually mature earlier than those high on the stalk.

The ears for seed should be left in the field to mature thoroughly. In gathering them, there should be left with the ears a small portion of the stalk with which they can be hung or placed in "halayhay" with the husk. In this way the ears should be kept stored and exposed to the sun to dry. Bunching together the unhusked ears and hanging them over a native stove is very effective in preserving seed corn. The smoke drives away weevils and other insects which attack the corn while the heat keeps the ears dry.

The "can method" of storing seed corn was found very satisfactory under Philippine conditions. By this method, the ears are shelled when they are reasonably dry. The grains are dried thoroughly in the sun on mats, cement floors, iron sheets, or any materials that can hold them. When the grains are thoroughly dry, they are put in empty cans with two or three naphthalene balls. The cans are sealed immediately with wax or paraffin. Gasoline or petroleum cans are very handy for this purpose.

Soil requirements.—While corn may be grown anywhere in the Philippines, a level or undulating ground that is well drained would be most ideal. The soil should be clayey, silty, or sandy loam with plenty of organic matter.

FERTILIZERS FOR CORN

Corn takes away from the soil large quantities of nitrogen, phosphorous and potash so that unless these elements are returned to the soil, either by the use of commercial fertilizers or manures, the soil will be depleted of them and corn growing will no longer pay.

The application of animal manure and compost will help in the maintenance of soil fertility.

Commercial fertilizers are very popular and are extensively used in sugar-cane growing. Rice planters are now beginning to use fertilizers too. According to Vibar, a mixture of 10 parts nitrogen, 6 parts phosphoric acid and 2 parts potash is as good as any combination that can be made in the absence of definite knowledge of the composition of the soil. One spoonful of fertilizer per hill has been found to be sufficient. At this rate of application, 100 kilograms of fertilizer will suffice for a hectare. Applications by the one-spoon-per-hill method, although requiring more time than the broadcast or the furrow method, are more efficacious and less wasteful than the latter.

Preparation of the soil.—The soil should be prepared thoroughly; the old corn stalks completely plowed under and allowed to rot and become incorporated with the soil. In the case of corn plantations which are infested with pests and diseases the old stalks should be burned.

It is advisable to prepare the soil during the beginning of the rainy season in April so that planting could be done during the first week of May.

At least three plowings are necessary to raise a good crop, especially in depleted soils. Thorough preparation of the soil gives the corn plant a good start and keeps down the weeds.

Planting.—The time for planting corn depends on the rainfall. In places where there is a distinct dry and wet season, two plantings of corn could be done on the same piece of land during the year, the first planting to be done at the beginning of the rainy season in April or May, and the second in October or November. The first planting is called the rainy season crop and the second, the dry season crop. In places where the rainfall is uniformly distributed throughout the year, where there is no distinct dry season, planting could be done at any time of the year.

Corn is planted in furrows about 90 to 100 centimeters apart and 60 to 70 centimeters between hills. Two to three seeds are planted to a hill at a depth of about 3 centimeters. Small varieties should be planted closer than large varieties. In rich soil they should be planted farther apart than in poor soil.

About six to seven gantas of seeds are needed to plant a hectare.

Cultivation and care of plantations.—The first cultivation is done when the plants are 15 to 20 cm. in height. Corn is a surface feeder, so that cultivations should not be made so deep

as to cut a considerable portion of the roots. A cultivator should be used in preference to the plow. In most places a plow is used in turning over the soil toward the rows of plants. During dry spells, the surface soil should be kept in fine tilth to provide the necessary soil mulching.

Method of cropping corn.—Corn should not be planted continuously on the same land from year to year as this will deplete or wear out the soil more quickly than when different kinds of farm crops are planted in rotation with it. Legumes as green manure should be plowed under 3 to 4 months before planting corn. It is recommended that every fourth crop on the same land should be leguminous. Peanut, mungo and cowpeas are good rotation crops for corn.

Harvesting and storing.—Ordinary varieties of corn mature in 85–110 days from the time of planting. The ears should be allowed to dry thoroughly in the fields before harvesting. Moist-ears or grains mold, and if stored, will either rot or germinate. During the rains in places where there is no distinct dry and wet season, considerable difficulty is encountered in drying corn. This difficulty can be minimized by having proper drying places and ample provisions of seed.

Harvesting is done by hand. The ears are detached from the stalks, husked and dried in the sun preparatory to shelling for the market. The shelling is done with the use of a hand-operated shelling device or machinery. The drying of the grains is completed after shelling. It is then ready for market. Marketing corn as ears is frequently done, if the grain is intended for seed.

In small plantations, corn can be conveniently kept on the "halayhay." The unhusked ears are set on bamboo slats under a shed or in open air.

Pests and diseases.—The corn plants are attacked by corn borers, cut worms, silk beetles, leafhoppers and aphids, and affected by corn smut, leaf-spots, downy mildew and blight. The grain is damaged by corn weevil.

The corn borer (*Pyrausta nubilalis* Rubn.).—The corn borer is one of the worst enemies of corn. The larvæ attack the stalk, tunnel up toward the tassel, bore into the stalk, and finally damage the ears. Infested plants are weakened so much that sometimes even an ordinary gust of wind can break the stalks. Indications of an infested field are broken tassels and the presence of frass or sawdust-like materials at the opening of the tunnel.

Control measures.—Infested corn stalks should be cut close to the ground and fed to animals. Those that are not eaten in the stables should be burned or buried deep so as to destroy all the larvæ and pupæ which may be present. The introduction of egg parasites will materially aid in the extermination of this pest. This requires the services of trained entomologists. Clean culture and the production of resistant varieties should not be overlooked.

The corn silk beetle (*Monolepta bifasciata* Hornst.).—This beetle was found to be very injurious to corn crops. The insects feed on the silk of the young ears and thus prevent fertilization.

Control measures.—The beetles can be controlled by attracting them to lights at night. It is suggested that the time of planting be arranged in such a way that the production of ears does not coincide with the abundance of the beetles. Trap crops, such as "kamoteng kahoy" could be used to great advantage.

These beetles also attack the young leaves of mango. When found abundant on this tree, they should be sprayed with arsenical insecticides or soap solution and derris so that the beetles would have no chance to infest corn fields.

True army worms (*Cirphis unipuncta* Haworth).—The larvæ of this insect attack all grass crops especially corn, rice and many other plants. When the larvæ infest corn crops, they defoliate the young corn plants thereby reducing greatly the vitality of the plants and consequently affecting adversely the harvest.

Control measures.—The adults could be controlled by the use of light traps. The larvæ could be killed by the use of poison bran mixture of the following composition (to be scattered in the field at the rate of 3–4 kilos to the hectare):

Dry bran	lbs.	25
Water	gallons	3
Molasses	quarts	2
White arsenic or Paris green	lb.	1

Dusting the plants with calcium arsenate-*gawgaw* dust mixture is also effective.

The rice or corn weevil (*Calandra oryzae* Linn.).—This is the worst enemy of stored corn, rice and many other stored grains. The larvæ tunnel into the kernels and consume all the contents

before they are transformed to pupæ while the adults puncture the kernels with their beaks for oviposition purposes.

Control measures.—To control the pest one is advised to:

(1) Dry thoroughly before storing corn ears or kernels.

(2) Store corn in tightly closed containers.

(3) Fumigate with carbon bisulphide at the rate of one tablespoonful for every cubic meter of space.

(4) Store seed corn with naphthalene balls.

Downy mildew (*Sclerospora philippinensis* Weston).—This is a serious disease of corn and is found to be severe during rainy season. The upper young leaves of the plants are the first to be affected. Diseased leaves are characterized by the presence of white stripes running parallel to the margin of the leaves. Oftentimes, the entire young leaves are whitened. A downy appearance is produced on the lower surfaces of the leaves by the mass of conidia and conidiophores.

Control measures.—All infected plants should be gathered and burned. Clean culture and crop rotation are recommended to prevent infection.

Leaf blight (*Helminthosporium inconspicum*).—Leaf blight is a common disease of corn, which at times may be extremely destructive. This disease is especially severe on newly introduced corn varieties. The disease is manifested by the presence of minute roundish brown spots, which gradually increase in size. Old spots and stripes have a lighter yellowish to gray center, bordered with brown.

Control measures.—Crop rotation should be practiced. Compost made up of diseased plants should not be applied the same year to fields intended for corn.

Other diseases of corn such as dry rot and smut are of minor importance.

Cost of production.—The cost of producing corn includes the cost of seeds, preparing the soil, planting, cultivating and weeding, harvesting, and other expenses. While it is true that there are many factors affecting the cost of production, the most important are the kind of seeds used, weather conditions, pests and diseases, fertility of the soil, cost of labor, system of tenancy and the market price.

The cost of producing corn per hectare at the Maligaya Rice Experiment Station, Bureau of Plant Industry, Muñoz, Nueva Ecija, is as follows:

Operation	Man labor		Animal Labor		Total cost	Implements
	Days	Cost	Days	Cost		
		Pesos		*Pesos*	*Pesos*	
Land preparation:						
1st plowing 1st harrowing	10	6.00	10	6.00	12.00	Wooden plow and wooden harrow.
2nd plowing 2nd harrowing	10	6.00	10	6.00	12.00	Do.
3rd plowing 3rd harrowing	6	3.60	6	3.60	7.20	Do.
Furrowing	1.5	.90	1.5	.90	1.80	Wooden plow.
Planting	1.5	.90			.90	
Cost of seeds					.75	
Cost of shelling					.20	
1st cultivation	2	1.20	2	1.20	2.40	Wooden plow.
2nd cultivation	2	1.20	2	1.20	2.40	Do.
3rd cultivation	2	1.20	2	1.20	2.40	Do.
Harvesting	2	1.20			1.20	
Hauling	1	.60	1	.60	1.20	Bull-cart.
Cost of sacks					2.50	
Total	38	22.80	34.5	21.60	46.95	

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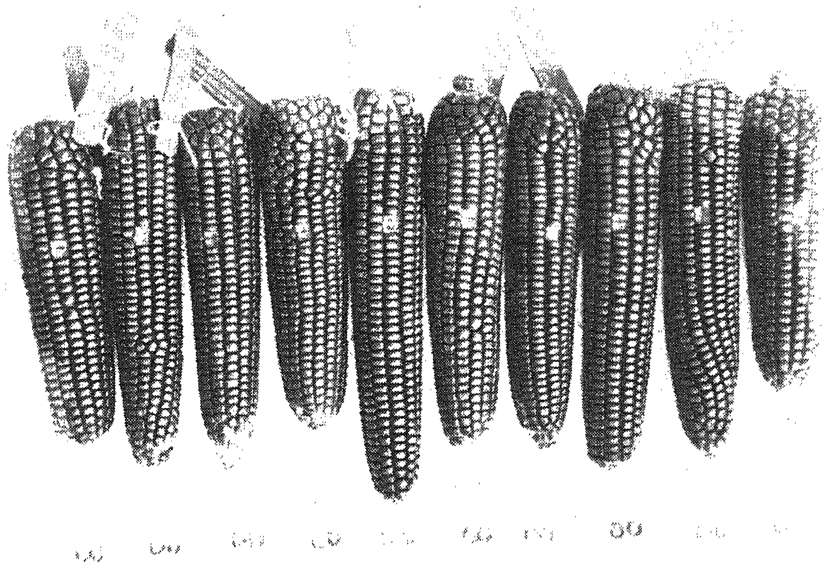
2. Philippine Statistical Review 5 (1938) Nos. 1–2.
3. VIBAR, TORIBIO. Corn in the Philippines. B. P. I. unnumbered circular (1932) 1–27.

ILLUSTRATIONS

[PHIL. JOUR. AGR., 10, No. 2.

PLATE 1.



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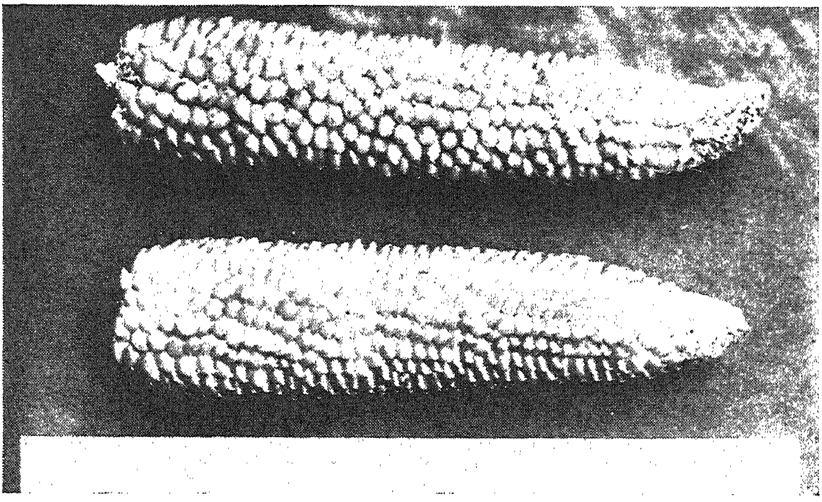

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PLATE 2.

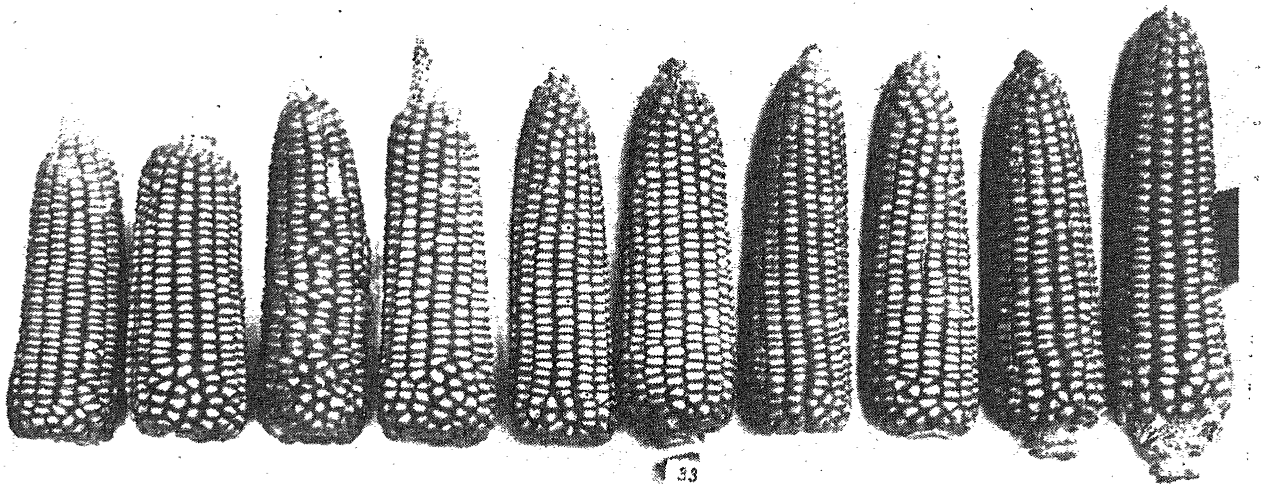


PLATE 3.

RICE LEAFHOPPERS

1. *Nephotettix apicalis* Motch.
2. *Nephotettix bipunctatus* Fabr.

Local names: Hanip (Tagalog), sip-sip (Ilocano), po-or or po-ol (Pangasinan)

(Farmers' Circular No. 49)

By Roman Abalos
Of the Plant Pest and Disease Control Division
Bureau of Plant Industry, Manila

TWO PLATES

Among the most serious pests of rice in the Philippines are two species of leafhoppers, known in science as *Nephotettix apicalis* Motch., and *Nephotettix bipunctatus* Fabr., both of the family Cicadellidae. These insects attack rice plants in all stages of growth and often cause considerable damage. The insects are usually abundant during the months of August, September, and October.

Since the insects destroy the rice plants by inserting their beaks into the leaves and the leaf sheaths and then suck the juice, they are called "sip-sip by the Ilocano farmers. These two species of leafhoppers prefer to stay on the leaf sheaths and on the leaves of the plants. The early sign of injury is the drying of the tip of the older leaves and the presence of yellow spots on the midribs and the leaf sheaths. The plants are stunted. In cases of serious infestations the plants appear as if burned, for which reason the farmers of Pangasinan call the trouble "po-ol" or "po-or." In the absence of rice plants, the insects feed on wild grasses growing in or near the rice field.

DESCRIPTIONS

Nephotettix apicalis Motch., is pale green in color with a length of from 5 to 5.5 mm. from the tip of the head to the tips of the wings. The head has a transverse black line connecting the two compound eyes. One third of its outer wing from the tip (apical third) is dark. The male has a black elongated dot on the middle of each outer wing, which is absent on the female. The full grown nymph is creamy with irregular markings on the body.

Nephotettix bipunctatus Fabr., closely resembles *Nephotettix apicalis* Motch., but the former is smaller, measuring from 4.5 to 5 mm. and has no transverse black line connecting the two compound eyes. The male has a black circular spot before the middle of each outer wing. The full grown nymphs are pale green.

LIFE HISTORY

The adults of these two species lay their eggs in rows inserted into the leaf sheaths of the tender plants just below the epi dermis. The eggs are about a millimeter long, whitish in color and can not be seen without the aid of a hand lens. The newly hatched nymphs undergo five molts before they become adults with fully developed wings. The life cycles of these two species are as follows:

	Days
Nephotettix apicalis Motch.	
Egg stage	7 to 9
Nymphal stage	14 to 19
Nephotettix bipunctatus Fabr.	
Egg stage	5 to 10
Nymphal stage	13 to 18

These two species of leafhoppers begin to lay their eggs 2 or 3 days after they emerge as adults.

CONTROL MEASURES

Since these two species have similar life histories and habits, the following control measures are suggested:

1. *Sweeping with net.*—A cone-shaped bag made of cheese cloth attached to a stiff circular wire and mounted on a short stiff wooden handle will serve the purpose. The net must be swung back and forth striking the leaves of the plants. The insects caught at the bottom of the net can then be killed by crushing them.

2. *The use of hopperdozer.*—An empty petroleum can should be cut longitudinally into halves along opposite corners. The inside surface of one of the halves should be smeared with tangle foot and a convenient handle nailed along one of its sides as shown in Plate 2, fig. 3. This is used in the same manner as a hand net, that is, it is swung back and forth touching gently the rice plants as the operator moves along. The disturbed leafhoppers will fly or jump and are caught by the tangle foot in the hopperdozer.

3. *Application of kerosene.*—If the field is still under water and the plants have but few leaves, application of kerosene helps much to control the pests. Kerosene should be applied to the paddy so that a thin film is formed on the surface of the water. By gently striking the plants with stick, rope or similar materials, the insects fall on the water and come in contact with the kerosene, which soon kills them by suffocation. Care should be taken, however, that kerosene is not excessively applied as to burn the plants. The water with the kerosene film should be drained off and replaced with fresh water after the insects have been killed.

4. *Light trapping.*—A lantern set on a basin of water coated with a thin film of kerosene may be used. Being attracted to light, the adult hoppers fly to the lantern, fall to the basin and thus get drowned. The moving light trap is recommended for this purpose. Two persons shall work side by side in the field at night, one carrying a lantern on a basin of water coated with kerosene, the other gently striking the rice plants with stick, rope or other similar materials. The disturbed leafhoppers will then fly to the light and fall to the basin where they get killed. This method of control by light trap should be employed early in the season in order to catch the adults before they lay eggs on the rice plants. According to the experiment conducted by the writer, this method of moving light trap can catch even twenty times more than the stationary light trap.

5. *Spraying with contact poison.*—Soap solution spray with a concentration of 8 grams of soft, yellow laundry soap per liter of water may be used. A pump with a good nozzle that will deliver a spray in a fine mist should be used. The plants should be sprayed thoroughly so as to moisten the insects. Spraying should be done once a week until the pest is well under control.

6. *Application of fertilizer.*—If the soil is poor fertilization should be practiced as this will make the plants more vigorous, thus rendering them more resistant to pests. A compound fertilizer containing from 10 to 20 per cent each of nitrogen and phosphoric acid may be applied at the rate of 100 to 150 kilos per hectare. Before applying, the surplus water in the field, if any, should be drained off to about an inch deep.

7. *Clean culture.*—In view of the fact that the pests subsist on wild grasses during the off season for rice, clean culture should be widely practiced by the farmers. Grasses on which

the pests may feed and breed should be burned or destroyed to at least minimize their number. During the planting season, the field should be thoroughly prepared and rid of weeds.

8. *Selection of variety.*—Good yielding varieties of rice plants growing in the locality may be found to be more resistant to the attack of the pests, if they are naturally rank growers.

9. *Encouragement of their natural enemies.*—Birds such as the common swallow, shrike, and golden-headed cisticola, and dragon flies, spiders, frogs and young mud fish feed on the nymphs and adults insects. As far as practicable, these natural enemies should be protected and their multiplication encouraged.

ILLUSTRATIONS

PLATE 1

Development of *Nephotettix apicalis* Motch.

FIG. 1. Portion of the stem of rice plant with eggs inserted just below the epidermis of the leaf sheath. ($\times 3$)
2. Egg. ($\times 20$)
3. First instar. ($\times 20$)
4. Second instar. ($\times 20$)
5. Third instar. ($\times 20$)
6. Fourth instar. ($\times 20$)
7. Fifth instar. ($\times 20$)
8. Adult female. (About $\times 20$)
9. Adult male. (About $\times 20$)

PLATE 2

Nephotettix bipunctatus Fabr.

FIG. 1. Adult female. (About $\times 20$)
2. Adult male. (About $\times 20$)
3. Diagrammatic drawing of hopperdozer.

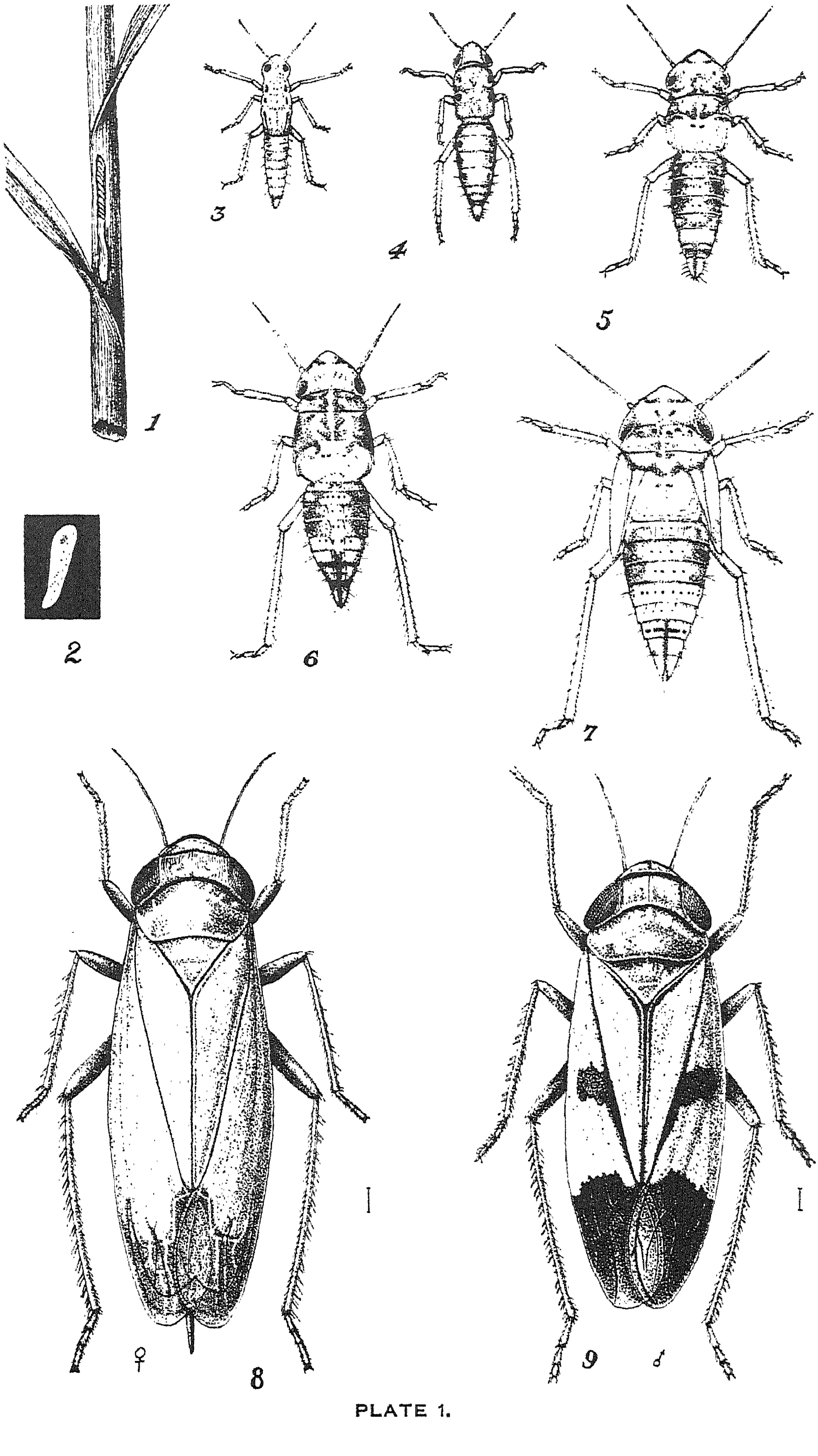
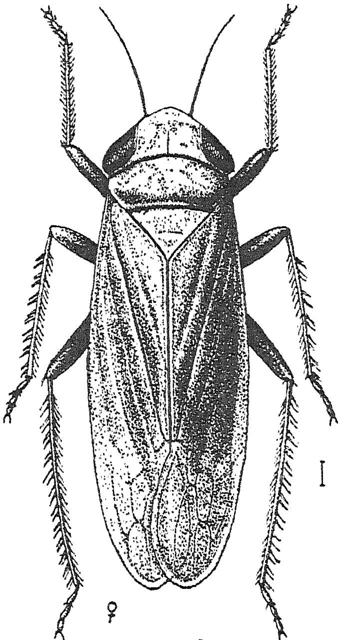


PLATE 1.



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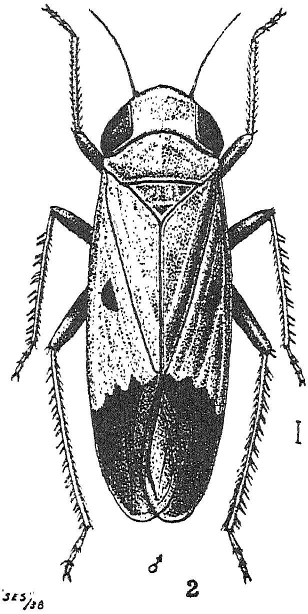

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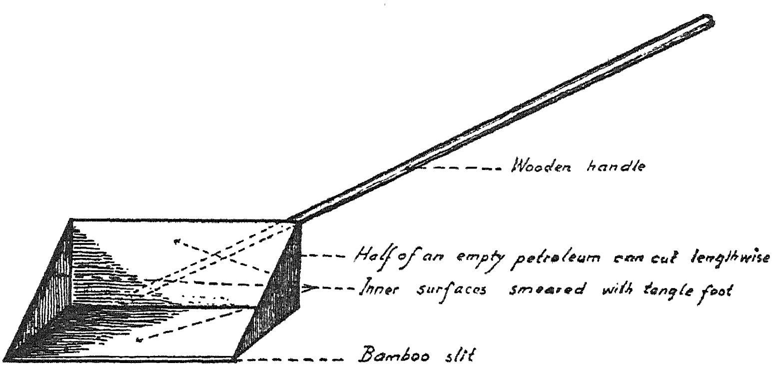

Diagramatic drawing of hopperdozer

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PLATE 2.

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PROGRESS REPORT ON THE BREEDING OF ABACÁ (*MUSA TEXTILIS* NÉE)

By J. P. TORRES and T. G. GARRIDO
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FIVE PLATES

Manila hemp or abacá, *Musa textilis* Née belongs to the genus Musa, family Musaceae, which is indigenous to the Philippines. This fiber plant has been in cultivation long before the white men discovered this country. The abacá fiber is an important contribution of the Philippines to the industrial world. Records show that at the time of Magellan's visit in Cebu in 1521, the weaving of abacá fiber was already widely spread in the Islands.(1) Copeland(2) also stated that, according to Dampier, the abacá was more or less extensively cultivated in Mindanao in 1686.

Past attempts to grow this plant in Florida, German East Africa, India, Indo-China, New Caledonia, Queensland and West Indies had invariably failed. Agriculturally speaking Java and Sumatra are far more advanced in many respects than the Philippines(2) and these two islands might in the near future take away from us our virtual monopoly of abacá fiber production. In fact, it is now believed that Borneo and Sumatra are gradually breaking the abacá monopoly of the Philippines. According to Alunan(3), Mr. H. T. Edwards, Fiber Expert of the U. S. Department of Agriculture and himself were not allowed by the Dutch Government to visit the abacá plantations

and factories in Sumatra. Obviously, the methods of abacá production in Sumatra are being kept secret by the Dutch Government.

The Philippines is now confronted with the problem of maintaining this abacá monopoly and placing the industry on a high level of efficiency. The solution seems to lie in the lowering of the cost of production, of which there are two important considerations. First, the general use of economical or labor-saving devices in the stripping of abacá fiber and second, the increase in production per unit area, which may be obtained by improved cultural methods and by the use of the superior strains that would give greater returns and fiber of a quality better than that of any of the existing varieties. It was with these things in mind that the breeding of abacá was instituted.

This paper gives a short history of the work in abacá breeding by the Philippine Government from 1906 to the present, the technique involved in the hybridization of abacá and the results so far obtained.

The main object of abacá breeding is to produce, determine and isolate new superior economic varieties in which high yield, good quality fiber and resistance to abacá bunchy-top and mosaic diseases, and other desirable characters are combined.

HISTORY OF ABACÁ BREEDING

Propagation of seed.—The earliest attempt in the Philippines to propagate abacá by seeds was made in 1906 in Lamao Experiment Station, Limay, Bataan Province. No promising strains from that planting have been isolated. The second attempt as cited by Labrador(4) was made in 1907 in La Carlota Experiment Station, La Carlota, Occidental Negros, and like the first trial, the results did not go further than to demonstrate the possibility of growing abacá from seeds.

In 1920, La Carlota Experiment Station planted again seeds of 22 different known varieties from Luzon and Mindanao and likewise, for some obvious reasons, no selection was made with these materials. Following this, in April, 1925 the former Guinobatan Abacá Experiment Station at Binogsakan, Guinobatan, Albay, grew seeds of the Tabaconon variety from Sorsogon, Sorsogon, from which some 200 seedlings were grown to maturity. The results of these studies showed that none of the seedlings were found superior to the old variety Tabaconon.

The fact that this plant is indigenous to this country and that there are at present many existing varieties or types which are not products of artificial hybridization, leaves no doubt that abacá seeds must in some way had been used as propagating materials in the early days. As far as the senior writer knows, while a youngster, he remembers that quantities of abacá seeds were ordered from Batangas to be grown in other places. In 1928 during the senior author's preliminary survey of abacá varieties in Albay and Sorsogon he was informed by some old abacá growers that abacá seeds were used in the early days in planting additional areas devoted to this crop. Some of the abacá plantations as claimed by some growers had existed for over 100 years without having been rejuvenated, and were found to consist of mixed varieties in a semi-wild state. The suckers and stocks of the most promising plants were gathered as planting materials for the development of the recently established plantations.

At Tiwi, Albay, the writer(5) with Mr. Pedro I. Cruz, Assistant Agronomist In Charge observed an interesting colored variety locally called *Ugarom.* In most respects this variety is very similar to the variety Itom which is commonly grown in Albay but the former is more vigorous and stocky with larger and taller stalks. According to an informant this *Ugarom* is a seedling progeny of Itom and is much more productive than the parent variety. The variety Ugarom deserves special attention to determine its merits and demerits in relation to abacá breeding work.

Hybridization.—The hybridization of abacá was once conducted in 1920 at La Carlota Experiment Station but the seeds obtained from the experiment did not germinate (reasons not stated) according to Labrador(4). Then in 1928 or about eight years later, crossing was done at the Guinobatan Abacá Experiment Station in Binogsakan, Guinobatan, Albay, by the senior author. In 1929 and 1930 the crossing experiments were performed by Mr. Pedro I. Cruz. The junior author did the hybridization work at Silang Abacá Disease Experiment Station, Silang, Cavite in 1931.

MATERIALS USED

In Guinobatan Abacá Experiment Station the following varieties were used: Itom, Lausigon, Maguindanao, Tan͠gon͠gon,

Puti-tumatagacan, Bulao, Libutanay, Inisarog, and Canton. In Silang, Cavite, the varieties employed were the Putian, Jolo-tigasin,[1] Jolo-lambutin,[2] Maguindanao, Sinibuyas and the Ki-nalabao.

METHODS OF BREEDING AND TECHNIQUE OF HYBRIDIZATION

Like most other perennial crops that may be propagated by rootstocks and suckers, there are in the breeding improvement of abacá four general methods used namely, (*a*) mass selection, (*b*) pedigree selection, isolation of superior hills, (*c*) production of seedling varieties from naturally produced seeds, and (*d*) production of superior hybrid seedlings by artificial hybridization. The last two methods had proved, with various economic plants, to be most practical, and satisfactory results had been obtained in a relatively shorter time. Hence, the last two methods are being used with abacá, special attention being given to artificial hybridization.

The flowers and their behavior.—The female flowers are distinguishable from the male flowers in that the former have miniature nonfunctional and rudimentary male organs or staminate parts and occupy the basal half of the entire inflorescence while the male flowers have nonfunctional pistillate parts(6), plate 1, fig. 1. An observation of their arrangement in the inflorescence shows that the female flowers are first developed, followed by the middle sets of flowers that are neither female nor male and then by the male flowers, so that the male flowers begin to function long after all the female flowers of the same inflorescence have ceased to function, plate 1 fig. 2(*b*). Obviously, under natural conditions abacá is a crosspollinated plant. It must be noted, however, that intercluster pollination or pollination of the female flowers of one plant by the pollen grains from another plant of the same clone takes place in the plantation. Wasps, ants, bees, and other insects and small birds are constant visitors of the abacá flowers and are, therefore, agents of pollination. The pollen grains are produced abundantly.

Technique of hybridization.—Abacá hybridization as an art consisted of collecting the male flowers laden with pollen from the selected male parent plant and then placing the pollen on the stigma of the female flowers of the selected female parent plant. The stigma is in the receptive stage as soon as it exudes a mucilaginous substance (stigmatic fluid) which catches the

[1] Hard to strip. [2] Soft to strip.

pollen grain and offers favorable conditions for its germination. The receptiveness of the stigma may last two days or more. No sooner was it fertilized than it turned brownish within 24 hours and shrivelled and withered afterwards. The female flowers were kept in bag before and after the stigmas had dried off or lost their power of receiving pollen. To obviate any possible contamination of pollen grains intended for crosspollination it was necessary to bag the male flowers until they opened or became ready to be used.

The senior author collected some hearts or panicles of male flowers, wrapped them with Manila paper, and then placed them on the table under the shed. In the following morning it was observed that the first two to three bracts of male flowers had opened, with mature pollen grains. The pollen grains that were produced during seven consecutive days from 10 to 15 bracts of the same hearts were used in crosspollination work and were found as effective as those freshly collected pollen grains from the plants in the same morning. This experience merely shows that some of the pollen grains normally develop and mature in the hearts that had been severed from the mother plants and that there is the possibility of transporting abacá pollen for hybridization work some distance with the present transportation facilities.

Germination of seeds, care and selection of hybrid seedlings.—The seed flats were prepared out of halved empty petroleum boxes, figure 3, almost filled with garden or sandy loam soil which was previously sterilized by direct heating in empty petroleum cans placed over an oven. In some cases boiling water was poured directly into the prepared seed flats at the rate of about a petroleum can for every four seed flats. A more or less thorough soil sterilization by this method is obtained by repeating the process 24 hours after the first sterilization.

Seeds were extracted from ripe fruits, plate 2, figure 2, and were washed to remove as much as possible all adhering fleshy substances with great care so as not to press the seeds too hard and so as to avoid bruising the delicate embryo in the seed. The clean seeds were spread in the shade for a short while thus draining off all the excess water. Direct sun drying was found to be very pernicious to the vitality of the abacá seeds.

The abacá seeds were then sown at a depth of about 1 centimeter in the seed flat at the rate of about 200 seeds per flat.

At this rate of seeding the overcrowding of seedlings which results in spindling growth of plants is more or less avoided.

After germination the seed flats were transferred to partially shaded benches where they were watered daily and carefully by means of a hand spray pump which turned out water in very small drops or fine mist. While very young, abacá seedlings are quite delicate and are likely to be injured by water poured out of an ordinary sprinkler.

Soon after a large number of the seedlings had developed 4 to 5 small leaves or when the seedlings were about 6 to 8 centimeters high, plate 3, figure 1(*b*), the weak seedlings were rogued out and the more vigorous ones pricked and transferred into other seed flats or pricking flats at the rate of 48 seedlings per flat. In the seed flats or pricking flats, they were allowed to develop and grow to about 1 to 1½ feet high when they were ready for transplanting into the nursery beds.

At this stage only the most vigorous seedlings were selected and transplanted to the nursery bed, discarding all the undesirable and inferior seedlings. This selection was based on certain arbitrary standard with respect to size and vigor of the seedlings.

Nursery beds.—A nursery bed may be briefly described as a portion of the field, prepared for planting the seedlings as soon as they reach a height of about one and a half feet. In this bed the seedlings are set out closer than those in the permanent field, using various spacings such as in (*a*) rows one meter apart and hills 50 centimeters apart in the row; (*b*) in double rows with a distancing of 50 centimeters apart each way and 1 meter between the double rows; or (*c*) one and a half meters between the double rows and 75 centimeters to one meter between plants in the rows, plates 3 and 4, figure 2. The junior author used a distance of 18 inches each way between adjacent hills.

Initial clone plots and clone multiplication plots.—The seedlings were grown in the nursery beds for some time until a large number of them became ready for transplanting in the Initial Clone Plot for Individual Plant Selection Test. The most vigorous and free from disease seedlings were selected. In the Initial Clone Plot the hills were set 3 meters apart each way either in squares or quincunx, and therein allowed to develop as many suckers as possible. Here the relative height of individual clones, the number of suckers or stalks produced and

the tensile strength per gram-meter of the fiber were studied and taken as the basis for a preliminary selection of individual hybrids or Initial Clone Selection. The clones to be selected from the Initial Clone Plots were then transplanted to the Clone Multiplication Plots for further clonal selection work. To test the resistance of individual hybrids to bunchy-top and mosaic diseases some rootstocks and suckers were recently transferred to the Abacá Disease Experiment Station at Silang, Cavite for inoculation experiments in coöperation with the Plant Pathology Section of the Bureau.

RESULTS

The results of abacá hybridization may be presented in two sequences, namely, the results of 1928 to 1930 and those of the 1931 hybridization work. Chronologically speaking, those performed in Albay were 1 to 3 years earlier than those worked out in Silang, Cavite, but it will be seen later in the discussion of results that the 1931 crosses had already been planted in the Clone Multiplication Plots whereas the earlier crosses are as yet in the Initial Clone plots. As affected by the reorganization of the Bureau's technical personnel, the senior author was assigned in 1930 in Lamao Experiment Station; in Tanauan Citrus Station a year later and then in 1933 he was sent to the Economic Garden, as a plant breeder to work on the breeding of perennial crops other than fiber crops. In January, 1935, on the organization of the Plant Breeding Section he was recalled to Manila. The junior author was then assigned with the section but as there was no permanent government experiment station all abacá breeding work in Guinobatan and Moriones had to be held in abeyance from 1931 to 1938, awaiting the establishment of a government owned experiment station. Naturally, the abacá breeding work suffered a great loss of materials leaving only five of the 19 successful crosses which were planted in the Initial Clone Plots. Now that the Guinobatan Abacá Experiment Station has been established at Banao, Guinobatan, Albay, the clonal selection and propagation of abacá hybrids resulting from the earlier crosses will therefore be carried out.

The results of the 1928–1930 hybridization work at Guinobatan Abacá Experiment Station, Binogsakan, Guinobatan, Albay are shown in tables 1 and 2 and those of 1931 conducted in Silang, Cavite are presented in tables 3, 4, 5, and 6.

DISCUSSION OF RESULTS

Results of the 1928–1930 abacá hybridization.—Out of 27 different crosses made in Guinobatan Abacá Experiment Station there were eight failures and nineteen successful crosses. Crosses Nos. 16 and 17 failed because of the fact that the Canton is an sterile hybrid (plate 5, figs. 1 and 2) producing no pollen grain at all and it is believed that the internal cause of its failure to produce pollen grain or its impotence(7) may have similar effect upon the production of mature ova or egg cells; or the failure to effect fertilization may be due to the excessive length of the style of Canton or something in there that may inhibit the normal growth of the abacá pollen tube. Cases of this nature had been registered with various plants(7).

From the 19 successful Guinobatan abacá crosses, over 36,800 hybrid seedlings had been produced, about 11,000 of which had been pricked in the seed flat. This number gave in turn about 5,000 seedlings grown in the nursery beds representing only five of the successful crosses, namely, Itom × Lausigon, Itom × Maguindanao, Puti-tumatagacan × Maguindanao, Puti-tumatagacan × Lausigon, and Maguindanao × Lausigon. The four crosses, marked *M* in table 2 with a total of 2,039 hybrid seedlings, were planted in the Initial Clone Plot in 1930 and 1931 in Moriones Propagation Station, Pili, Camarines Sur and 585 hybrid seedlings of Maguindanao × Lausigon were transplanted on August 29, 1929 in the Initial Clone Plot in the Guinobatan Abacá Experiment Station, Binogsakan, Guinobatan, Albay. Obviously, the number of hybrid seedlings planted in the Initial Clone Plots represent only about 8.2 per cent of the total number of hybrid seedlings produced. This percentage should have been much more if the selection and transplanting had not been abandoned for reasons stated elsewhere in this report.

During the last visit of the senior author in April, 1938, the Initial Clone Plot in Moriones Propagation Station was in very poor shape, having been given very little or hardly any attention since it was established in 1931 and the weeds grew abundantly, and the plantation suffered from fire two times. It was also noted that the place because of its low altitude and more or less clayey soil where the plot was established is by far not particularly suitable for the growing of abacá. In spite of unsuitable soil conditions with almost complete neglect and calamities which befell the plantation there were found some 212 hybrid clones consisting of the four different crosses and rep-

TABLE 1.—*Different crosses and number of seedlings produced at Guinobatan Abacá Experiment Station, Binogsakan, Guinobatan, Albay.*

Cross number	Kind of crosses	Date started	1929	1930	1931	Total
1	Itom × Lausigon	10-15-28	4,918	1 600		6 518
2	Itom × Maguindanao	10-25-28	3 823	3 200		7 023
3	Maguindanao × Lausigon	10-18-28	3,032	480		3 512
4	Maguindanao × Tañgoñgon	11-11-28	486			486
5	Puti-tumatagacan × Maguindanao	11-18-29	2 017			2 017
6	Bulao × Lausigon	3-21-29	2 450	937		3 387
7	Bulao × Tañgoñgon	4-13-29	450	698	97	1,245
8	Bulao × Maguindanao	4-13-29	2,224	224		2 448
9	Lausigon × Tañgoñgon	4-20-29	200	895	256	1 351
10	Libutanay × Tañgoñgon	4-25-29	720			720
11	Puti-tumatagacan × Libutanay	4-26-29	684			684
12	Lausigon × Maguindanao	5-23-29	1 600	1 020		2 620
13	Itom × Tañgoñgon	4-10-29	1,040			1 040
14	Inisarog × Maguindanao	6-26-29		1 505		1 505
15	Puti-tumatagacan × Lausigon	6-28-29		1 071		1,071
16	Canton × Maguindanao	4-21-29	failure			failure
17	Canton × Tañgoñgon	4-30-29	failure			failure
18	Samina × Maguindanao	7-11-29	failure			failure
19	Amokid × Lausigon	9- 7-29	failure			failure
20	Samina × Amokid	10-20-29	failure			failure
21	Lausigon × Pacol	12-31-29	failure			failure
22	Lono × Alman	1-19-30	failure			failure
23	Alman × Maguindanao	1-23-30	failure			failure
24	Lausigon × Bulao	11- 2-30			698	698
25	Samina × Bulao	11- 5-30			329	329
26	Carnajon × Samina	11- 8-30			130	130
27	Inisarog × Samina	11- 9-30			50	50
	Total seedlings produced		23 644	11 630	1,560	36 834

TABLE 2.—*Different crosses and number of seedlings pricked and number planted in the nursery and in the Initial Clone Plots.*

Cross number	Kind of crosses	Total number of seedlings	Number of seedlings pricked	Number in nursery plots	Number of hybrids in Initial Clonal Plots
1	Itom × Lausigon	6 518	3 740	2.500	[a] 1.171
2	Itom × Maguindanao	7 023	1.490	930	[a] 662
3	Maguindanao × Lausigon	3 512	785	785	[b] 585
4	Maguindanao × Tañgoñgon	486	486	None	None
5	Puti-tumatagacan × Maguindanao	2 017	1 097	920	[a] 178
6	Bulao × Lausigon	3 387	2 125	([c])	([c])
7	Bulao × Tañgoñgon	1 245	450	([c])	([c])
8	Bulao × Maguindanao	2 448	([c])		
9	Lausigon × Tañgoñgon	1 351	200	([c])	
10	Libutanay × Tañgoñgon	720	720	([c])	
15	Puti-tumatagacan × Lausigon	1.071	([d])	([d])	[a] 28
	Total	29 778	11,093	5 135	2,624

[a] Planted in 1930 and 1931 in Moriones Propagation Station, Pili, Camarines Sur. Area 1.84 hectares.
[b] Planted, August, 1929 in Guinobatan Abacá Experiment Station, Binogsakan, Guinobatan, Albay. Area 0.44 hectar.
[c] All discarded.
[d] No record.

resenting 10.4 per cent of the original number of transplanted hybrid seedlings.

The Maguindanao × Lausigon cross in the Initial Clone Plot in Binogsakan was likewise almost completely neglected and therefore had a very poor stand. There were counted 85 living clones which represented about 15.2 per cent of the total number of seedlings transplanted on August 29, 1929.

Apparently, many of the surviving clones in the two breeding plots may be regarded as inherently resistant to insufficient care. Some of the clones in these two breeding plots in Moriones and Binogsakan appear to be of superior types and, needless to state, they should receive the much needed attention and support in order to expedite their selection and multiplication for subsequent distribution.

TABLE 3.—*Results of 1931 abacá hybridization work at Silang Abacá Disease Experiment Station, Cavite.*

Cross number	Kind of crosses	Date crossed	Number of bunches crossed	Number of bunches successfully crossed	Remarks
28	Maguindanao × Putian	12-5-31	4	4	
29	Putian × Maguindanao	12-5-31	2	2	
30	Putian × Kinalabao	12-3-31	2	2	
31	Kinalabao × Putian	12-3-31	2	1	
32	Putian × Jolo-tigasin	12-5-31	2	1	
33	Jolo-tigasin × Putian	12-5-31	1	0	Failure.
34	Putian × Jolo-lambutin	12-5-31	2	1	
35	Jolo-lambutin × Putian	12-5-31	2	2	
36	Maguindanao × Kinalabao	12-8-31	2	2	
37	Kinalabao × Maguindanao	12-8-31	2	0	Failure.
38	Maguindanao × Sinibuyas	12-9-31	4	0	Do.
39	Sinibuyas × Maguindanao	12-9-31	2	0	Do.
40	Putian × Sinibuyas	12-4-31	1	1	
41	Sinibuyas × Putian	12-4-31	1	1	
42	Punukan × Putian	12-5-31	2	1	Discarded.
43	Putian × Punukan	12-5-31	1	0	Failure.
44	Kinalabao × Sinibuyas	12-4-31	1	1	Discarded.
45	Sinibuyas × Kinalabao	12-4-31	1	1	Do.
46	Balunan × Punukan	12-9-31	1	0	Failure.
47	Punukan × Balunan	12-9-31	1	0	Do.
48	Tañgoñgon × Putian	12-9-31	1	0	Do.
49	Putian × Tañgoñgon	12-9-31	1	1	Discarded.
50	Canton × Kinalabao	12-3-31	2	0	No seeds produced.
51	Canton × Sinibuyas	12-3-31	2	0	Do.
52	Canton × Sinamoro-puti	12-4-31	2	0	Do.
53	Canton × Maguindanao	12-5-31	2	0	Do.
54	Canton × Putian	12-7-31	2	0	Do.

Be it stated in passing that the Maguindanao variety which was introduced from Davao about 13 years ago in the former Guinobatan Abacá Experiment Station, did not progress as it was completely destroyed by the several typhoons which, during the first five years, hit the station since it was planted in 1925. Presently, nowhere in that station could the original Maguindanao variety be found. Its susceptibility to wind or typhoons may be attributed to the poor or scanty root system. On the other hand, many of the Maguindanao hybrid seedlings in both the Moriones and Binogsakan breeding plots had proved quite vigorous, more prolific in producing suckers, and better adapted to lower altitudes and more or less superior for having much stronger root systems than the parent Maguindanao stocks. Indeed there are very good indications that the value of some of these Maguindanao hybrids to our abacá industry in the near future cannot at present be underestimated.

Results of 1931 hybridization.—Twenty seven different crosses, Nos. 28 to 54 inclusive, have been made, using 48 bunches as shown in table 3. Only 14 of the crosses came out successful with 21 successfully crossed bunches. The failure of the 5 Canton × Abacá crosses may be attributed to the same reason stated in the results of the 1928–1930 hybridization, i.e., sterility or impotence of the seed parent, Canton. Twelve of the abacá crosses also failed to produce bunches as they were destroyed by high winds before the maturity stage. Four of the abacá crosses, Nos. 42, 44, 45 and 49 which produced crossed bunches may also be considered failures because they produced nongerminable seeds for reasons not yet studied. Morphological studies of the embryo formation in such cases may throw some light as to the cause or causes of the production of non-viable seeds. Taking all the decided failures into account only 10 out of 27 different crosses may, therefore, be considered successful.

The 10 successful crosses gave in round number about 10,000 hybrid seeds which were grown in 1932 in the erstwhile Plant Pathology Laboratory at Pandacan, Manila. The selection of vigorous and healthy seedlings for nursery planting was also performed thus eliminating all the inferior and the weaklings. And, in November, 1932, some 1,500 abacá hybrid seedlings were selected and brought to the Economic Garden at Los Baños,

TABLE 4.—*Number of F_1 hybrid seedlings and suckers of parent varieties grown in the nursery plot, and Initial Clonal Plots in the Economic Garden and Mount Makiling.*

Cross number	Kind of crosses and parent varieties	No. F_1 hybrids selected in the nursery and number planted in the Initial Clone Plots			
		Nursery (1932)	Plot A, Economic Garden (1933)	Plot B, Mt Makiling (1933–34)	Total F_1 seedlings
28	Maguindanao × Putian	300	12	22	34
29	Putian × Maguindanao	100	([a])	11	11
30	Putian × Kinalabao	200	6	11	17
31	Kinalabao × Putian	150	6	([a])	6
32	Putian × Jolo-tigasin	300	([a])	59	59
34	Putian × Jolo-lambutin	100	([a])	12	12
35	Jolo-lambutin × Putian	100	6	([a])	6
36	Maguindanao × Kinalabao	100	2	39	41
40	Putian × Sinibuyas	50	([b])		
41	Sinibuyas × Putian	100	([b])		
	Putian (parent)		5	6	11
	Kinalabao (parent)		4	2	11
	Maguindanao (parent)		6	7	6
	Jolo-tigasin (parent)		3	12	12
	Jolo-lambutin (parent)		6	7	7
	Total F_1 hybrid seedlings	1,500	32	154	189

[a] None. [b] Discarded.

Laguna, and set out in the nursery plot 18 inches each way between hills. The number of seedlings of each of the different crosses is shown in table 4.

After about a year in the nursery a very careful selection was again performed, thus resulting in the isolation of 186 most vigorous hybrid seedlings, 32 of which were planted in October, 1933, in the Initial Clone Plots in the Economic Garden and 154 hybrids in December, 1933, and January, 1934 in Mount Makiling. Apparently, out of 1,500 seedlings grown in the nursery only 186 or 12.4 per cent were isolated, consisting of 34 of Maguindanao × Putian, 11 of Putian × Maguindanao, 17 of Putian × Kinalabao, 6 of Kinalabao × Putian, 59 of Putian × Jolo-tigasin, 12 of Putian × Jolo-lambutin, 6 of Jolo-lambutin × Putian, and 41 of Maguindanao × Kinalabao. The 150 hybrid seedlings from the crosses of Putian × Sinibuyas and its reciprocal cross were all discarded in view of their poor behavior in the nursery. The distance in the Initial Clone Plots was 3 meters each way.

The F_1 hybrids and the parent varieties were allowed to grow and multiply in the Initial Clone Plots for about 3 to 4 years

and then further selection was made, thereby giving consecutive clone number irrespective of the kind of crosses from which they were obtained. To date there have been selected out of 186 F_1 clones, 100 which were propagated in four Clone Multiplication Plots, and in the test plot for resistance to bunchy-top (see tables 5 and 6).

In the Clone Multiplication Plots the plants were set out 4 meters between rows and 4 meters between hills in the row so as to give ample space for the full development and suckering of the individual plants.

The Clone Multiplication Plot 1–EG which was established in September, 1937 in the Economic Garden contains 23 selected clones consisting of 575 hills or 25 hills per clone. The planting materials were all taken from the Initial Clone Plot A. The area of this Clone Multiplication Plot is about 9,600 square meters.

At about the same time the Clone Multiplication Plots Nos. 2 and 3 were established. All the planting materials used in these two plots were obtained from the Initial Clone Plot B in Mount Makiling. The 30 selected clones, Nos. 24 to 53, inclusive, consisted of 641 hills covering a total area of about 13,328 square meters which included one row of 18 hills of Putian (P_1) and 1 row of 22 hills of Maguindanao (M_1) parents. P_1 and M_1 refer to clonal lines of parent varieties.

The Clone Multiplication Plot No. 4 which was established in July, 1938 in the Economic Garden covers an area of about 14,100 square meters and contains 24 different hybrid clones comprising 544 hills and 12 parental clones of 247 hills. Summarizing, therefore, there are in these four Clone Multiplication Plots 73 selected hybrid clones of 1,750 hills and 14 parental clones comprising 287 hills. The total area of the four clonal multiplication plots is about 37,028 square meters or 3.7 hectares.

Study on the resistance of abacá hybrids to bunchy-top disease.—Studies on abacá hybrids resistant to one of the most important diseases of abacá such as the bunchy-top, has been and is being administratively relegated to the Plant Pathology Section due to lack of personnel and facilities in the Plant Breeding Section. This fact has to be mentioned here because plant breeding results, obviously, will remain incomplete until some resistant hybrid strains have been isolated. The interest of the breeders in this connection lies not merely in the selection

TABLE 5.—*Crosses and hybrids selected and parent varieties from the Initial Clone Plots and transplanted in the Clone Multiplication Plots.*[a]

Multiplication plot number	Cross number	Kind of crosses	No. F_1 hybrids or clones selected	Clone number	Row number	Total hills
1. Economic Garden	29	Maguindanao × Putian	A12–8	3–7 and 14–16	3–7 and 14–16	200
EG	30	Putian × Kinalabao	A 6–6	8, 9 and 17–20	8, 9 and 17–20	150
	31	Kinalabao × Putian	A 6–2	1 and 2	1 and 2	50
	35	Jolo-lambutin × Putian	A 6–5	10, 11 and 21–23	10, 11 and 21–23	125
	36	Maguindanao × Kinalabao	A 2–2	12 and 13	12 and 13	50
2. Mount Makiling	28	Maguindanao × Putian	B22–7	33–39	7–13	154
	29	Putian × Maguindanao	B11–2	40 and 41	15 and 16	36
	32	Putian × Jolo-tigasin	B59–3	24–26	1, 3 and 4	58
	36	Maguindanao × Kinalabao	B39–2	29 and 30	5 and 6	40
[b]		Putian (parent)	B 6–1	P_1	2	18
		Maguindanao (parent)	B 7–1	M_1	14	22
3. Mount Makiling	29	Putian × Maguindanao	B –4	42–45	7–10	90
	30	Putian × Kinalabao	B11–6	46–51	11–16	141
	32	Putian × Jolo-tigasin	B –2	27 and 28	3 and4	42
	34	Putian × Jolo-lambutin	B12–2	52 and 53	5 and 6	42
	36	Maguindanao × Kinalabao	B –2	31 and 32	1 and 2	38
4. Economic Garden[b]	28	Maguindanao × Putian	A and B–6	14, 61–65	29, 5, 9, 18, 21 and 34	130
EG	29	Putian × Maguindanao	B –2	59 and 60	3 and 14	48
	30	Putian × Kinalabao	A –2	17 and 71	19 and 30	45
	31	Kinalabao × Putian	A –3	69, 70 and 2	17, 20 and 28	65
	32	Putian × Jolo-tigasin	B –5	54–58	1, 2, 6, 12 and 15	126
	35	Jolo-lambutin × Putian	A –3	72, 73 and 11	22, 31 and 32	65
	36	Maguindanao × Kinalabao	B –3	66–68	4, 8 and 10	75
		Maguindanao (parent)	–3	M2–M4	7, 23 and 25	68
		Jolo-lambutin	–2	J1–J2	11 and 16	47
		Jolo-tigasin	–3	T1–T3	13, 27 and 33	65
		Kinalabao	–2	K1 and K2	24 and 26	46
		Putian	–2	P2 and P3	35 and 36	21

[a] Multiplication plot Nos. 1, 2 and 3 were planted September, 1937 and plot No. 4 in July, 1938.

[b] Clones planted in Multiplication plot 4 EG. rows 1–16 were from Initial Clone Plot B in Mt. Makiling and those in rows 16–36 were from Initial Clone Plot A in the Economic Garden, Los Baños, Laguna.

TABLE 6.—*Abacá F_1 hybrids planted in November, 1938 in Silang Abacá Disease Experiment Station for disease-resistance studies.*[1]

Cross number	Kind of crosses or varieties	Clone number	Row number	Hill number	Total hills
29	Putian × Maguindanao	61	1	1–8	8
	Do	74	1	9–15	7
	Do	33	2	1–5	5
	Do	62	2	6–13	8
	Do	75	2	14–15	2
	Do	34	3	1–8	8
	Do	35	3	9–13	5
	Do	75	3	14–15	2
	Do	76	4	1–6	6
	Do	37	4	7–14	8
	Do	75	4	15	1
	Do	77	5	1–5	5
	Do	38	5	6–15	10
32	Putian × Jolo-tigasin	78	6	1–9	9
	Do	79	6	10–15	6
	Do	80	7	1–5	5
	Do	81	7	6–11	6
	Do	82	7	12–15	4
	Do	83	8	1–3	3
	Do	84	8	4–9	6
	Do	85	8	10–15	6
	Do	86	9	1–5	5
	Do	87	9	6–10	5
	Do	88	9	11–15	5
	Do	89	10	1–6	6
30	Putian × Kinalabao	90	10	7–14	8
	Do	91	11	1–8	8
	Jolo-tigasin (parent)	T4	11	9–15	7
32	Putian × Jolo-tigasin	92	12	1–15	15
34	Putian × Jolo-lambutin	93	13	1–15	15
	Do	94	14	1–6	6
36	Maguindanao × Kinalabao	95	14	7–12	6
	Do	96	14	13–15	3
	Do	96	15	1–3	3
	Do	97	15	4–9	6
	Do	98	15	10–15	6
	Do	98	16	1–9	9
	Do	99	16	10–15	6
	Do	100	17	1–10	10
	Do	67	17	11–15	5

[1] All F_1 hybrid clones in this plot were obtained from Initial Clone Plot B, in Mt. Makiling.

of varieties and production of hybrids but also in the testing of each of their individual selections for superiority, be it in yields, quality or in their reaction to natural enemies. Apparently, as mentioned above, the studies on hybrid strains resistant to bunchy-top disease are now in progress under the supervision of the Plant Pathology Section. The breeder's part in this connection is no more than to furnish materials for these studies.

The progress of these studies, while yet under our direction, is hereby reported.

Using the aphids, *Pentalonia nigronervosa* Coq. in the transmission of bunchy-top disease, inoculation test was conducted in August, 1936, in the two Initial Clone Plots, but 12 days after inoculation, all the inoculated plants were dug out by the order of the then Chief, Fiber Research Section, and the aphids were destroyed and killed by spraying them thoroughly with strong soap solution. Most of the plants and rootstocks in the inoculated hills were burned *in situ* and only 8 F_1 plants, each of Kinalabao × Putian, Maguindanao × Putian and Jolo-tigasin × Putian were saved and transferred to the Abacá Disease Experiment Station, Silang, Cavite, and planted on September 5, 1936. As of December 31, 1938 only three of the first cross, one each of the second and third crosses remained alive. The heavy mortality of hybrids in this planting was not due to the bunchy-top disease but due to very poor and too small planting materials coupled with the unfavorable weather conditions at planting time.

Were it carried out as planned by the senior author, obviously, we would at the present writing be in a better position to tell something on the relation of our abacá hybrids with the bunchy-top disease. Unfortunately, as it is now, because the former plan was somewhat modified by the Chief, Fiber Research Section, the resistance to bunchy-top of over 1,700 hills of hybrids in the multiplication plots is still doubted, and will remain so until each clone has been judiciously tried for bunchy-top resistance.

In October, 1938 another shipment to Silang Abacá Disease Experiment Station of abacá hybrids and parents was made, as may be seen in the following list:

Cross No.	Crosses and varieties	Clone No.	Number of plants
33	Maguindanao × Kinalabao	66	5
28	Maguindanao × Putian	61	5
32	Putian × Jolo-tigasin	58	6
	Jolo-tigasin (parent)	T_1	6
	Jolo-lambutin (parent)	J_1	4

The afore-mentioned materials were suspected of being affected by the bunchy-top disease in the Economic Garden so they were transferred and planted in Silang for further observation.

In November, 1938, another shipment to Silang Abacá Disease Experiment Station was made for the purpose of testing the resistance of the individual hybrid clones to bunchy-top disease of abacá. This collection consisted of 37 different hybrid clones and one parental clone, each cross numbering from 2 to 15 different clones with a total of 246 hills of hybrid forms. The hills were set 3 by 3.5 meters apart and the total area of the test plot was about 2,656 square meters.

All available crosses except cross No. 31, Kinalabao × Putian and cross No. 35, Jolo-lambutin × Putian, had been represented and of the 100 selected clones of the six different crosses only 39 clones were under disease-resistance tests, so there remained 61 clones yet to be subjected to inoculation test with bunchy-top disease and, as soon as possible, the suckers of each of these clones should be sent to Silang Abacá Disease Experiment Station.

At this juncture it is important to note that according to Calinisan and Hernandez(8) the Putian variety showed relatively high degree of resistance to bunchy-top disease. As a parent variety it is expected to produce resistant and superior hybrids when crossed with either the Maguindanao, the Tañgoñgon and other improved standard varieties.

Heterosis in abacá hybrids.—A preliminary study was made on the number of suckers produced by the individual hybrids in the Initial Clone Plots. The height of mature plants, basal, middle and top diameter, percentage and tensile strength of fiber had also been determined for comparison with the parent varieties. Any significant increase in these characters excepting perhaps in the last two characters of the hybrids as compared with the parents is believed to be due to the probable effect of heterosis. The data on the average number of suckers are presented in table 7, whereas, those of other characteristics studied will be presented in the next report on the studies of individual abacá crosses and hybrids for the selection of superior hybrid strains, a report which will also be published in this journal.

It can be seen in table 7 that the average number of suckers of F_1 hybrids of different crosses is in general larger than that of either parents or their corresponding averages and the percentage gain ranges from 46.7 to 85.1 per cent. Apparently, this general increase in the average number of suckers in the

TABLE 7.—*Comparison between parent abacá varieties and F_1 hybrids in the number of suckers produced*

Parent and crosses	Number of clones	Average number of suckers	Average F_1 minus average parents	
			Number of suckers	Per cent
Initial clonal plot A Economic Garden				
Maguindanao (parent)	6	14.0		
Putian (parent)	5	9.0		
Kinalabao (parent)	4	7.4		
Jolo-lambutin (parent)	6	12.4		
F_1 Maguindanao × Putian	12	20.4	8.9	77.4
F_1 Putian × Kinalabao	6	15.0	6.9	85.1
F_1 Jolo-lambutin × Putian	6	15.7	5.0	46.7
Initial clonal plot B Mount Makiling				
Putian	6	16.0		
Jolo-tigasin	12	13.0		
Maguindanao	7	11.0		
Kinalabao	2	8.4		
F_1 Putian × Jolo-tigasin	59	22.5	8.0	55.2
F_1 Putian × Kinalabao	11	19.0	6.8	55.7
F_1 Maguindanao × Putian	22	23.0	9.5	70.4

two Initial Clone Plots is due to hybrid vigor or heterosis in the F_1 generation.

SUMMARY AND CONCLUSIONS

This paper gives the history of abacá breeding since 1906 and the technique of abacá hybridization.

Of the 54 different crosses attempted from 1928 to 1931 only 29 crosses were successful, 19 crosses in Guinobatan Abacá Experiment Station, Binogsakan, Guinobatan, Albay and 10 crosses in Silang, Cavite.

Because of a shift in the Bureau's personnel, and because of failure to establish a government owned station until 1938, only 5 of the 1928–1930 crosses had been transplanted in the Initial Clone Plots. Those propagated in Moriones are the Itom × Lausigon, Itom × Maguindanao, Puti-tumatagacan × Maguindanao and Puti-tumatagacan ×Lausigon and the only cross planted in the Binogsakan Initial Clone Plot is the Maguindanao × Lausigon. The superior seedlings that may be selected from the two breeding plots in Moriones and in Binogsakan should receive the much needed attention and support to facilitate propagation and subsequent distribution.

Eight of the 10 successful crosses among the 1931 crosses are at present in the Clone Multiplication Plots. Out of 186 clones in the Initial Clone Plots, 100 different clones had been selected. Of the 100 selected clones only 39 are under disease-resistance test at Silang Abacá Disease Experiment Station and 61 are as yet to be, as soon as possible, subjected to similar test. The four Clone Multiplication Plots cover an area of about 3.7 hectares while the disease-resistance test plot is about 0.3 hectare.

It was observed from the results of seven different matings that the Canton, a pollenless and seedless form of *Musa,* is cross-sterile with abacá using the latter as pollen parent.

Heterosis was observed in the F_1 hybrid of abacá crosses and its effect showed that the F_1 generation hybrids produced greater number of suckers than either parents, ranging from 46.7 to 85.1 per cent.

Compared with the Maguindanao parent variety the Maguindanao hybrids are better adapted to conditions and possess stronger root systems. Hence the value of the Maguindanao hybrids in the future abacá industry cannot at present be underestimated. It is hoped, however, that their hybrids with the Putian variety would be as resistant to bunchy-top disease as the Putian variety.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to Mr. Pedro I. Cruz, assistant agronomist (of the former Guinobatan Abacá Experiment Station) who, in fact, performed the different experiments on crossing in 1929 and 1930 and grew the seeds and, together with Mr. Domingo S. Baybay, established the Initial Clone Plots in Moriones and in Binogsakan; to Mr. H. T. Edwards, technologist of the U. S. Department of Agriculture, who read the first draft of this progress report; and to the Acting Chief of the Fiber Research Section, Mr. Eladio Sablan, who gave this project his moral and material support.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Left, pistillate or female flowers; right, staminate or male flowers. Note the specialized parts of the two kinds of flowers.

2. (*a*) Right, newly opened heart with some pistillate flowers ready for pollination; (*b*) left, staminate flowers.

PLATE 2

FIG 1. Left, sterilized soil; middle, germinating abacá seeds; right, seedlings ready for nursery planting.

2. A hand of abacá fruits. Note seeds shown in the sections.

PLATE 3

FIG. 1. Abacá seedlings in different stages: (*a*) Very young seedlings; (*b*) at pricking stage; (*c*) not quite ready for nursery setting.

2. Partial view of the nursery showing some promising Itom × Lausigon seedlings.

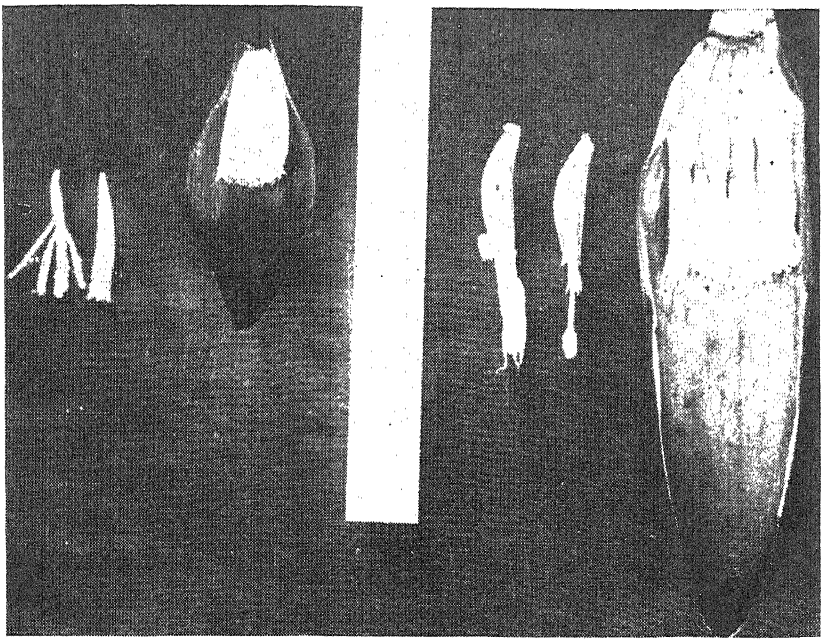
PLATE 4

Partial view of the abacá hybrid nursery in Binogsakan, Guinobatan, Albay, with seedlings of different abacá crosses.

PLATE 5

FIG. 1. A bunch of seedless Canton fruits.

2. A hand of Canton seedless fruits and sections showing absence of seeds.



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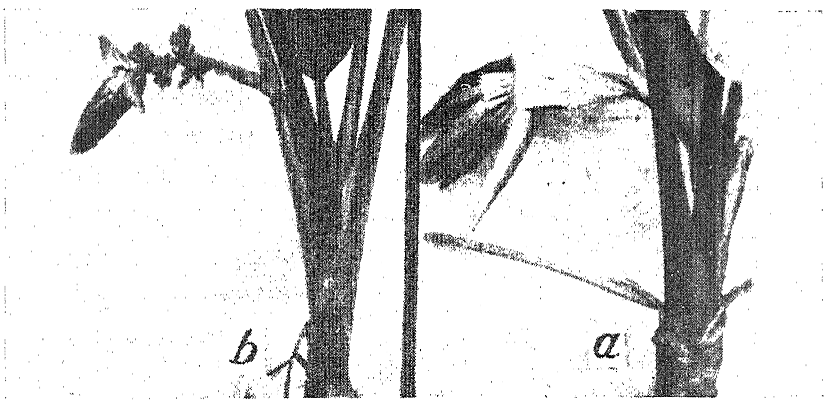

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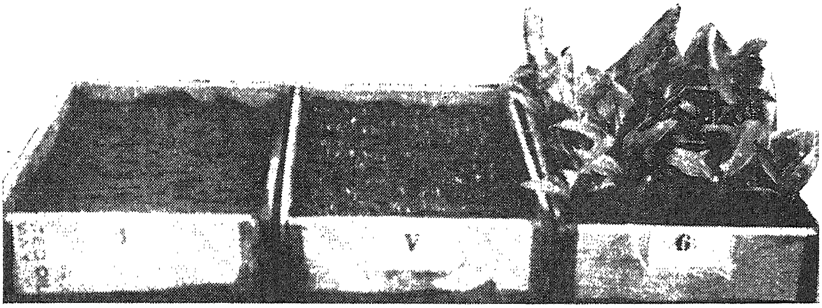
PLATE 1.



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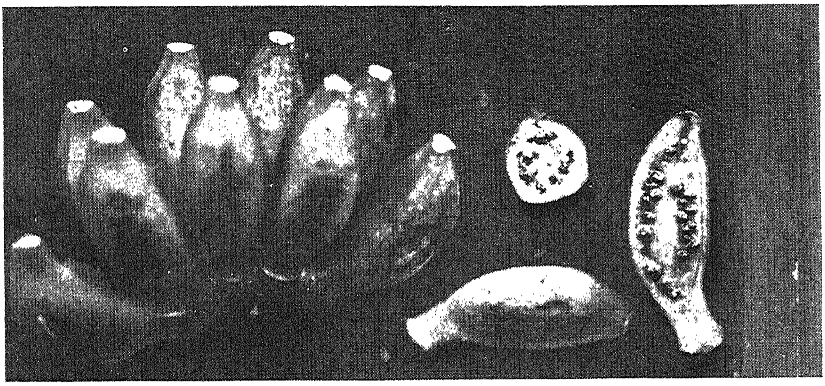

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PLATE 2.

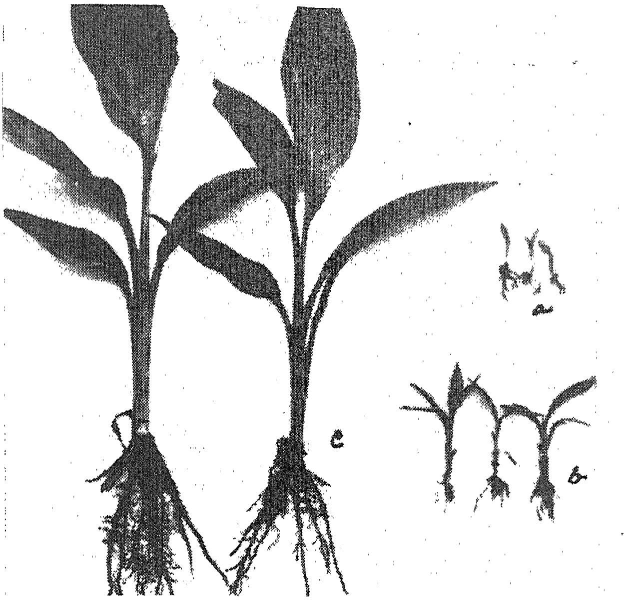

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PLATE 3.

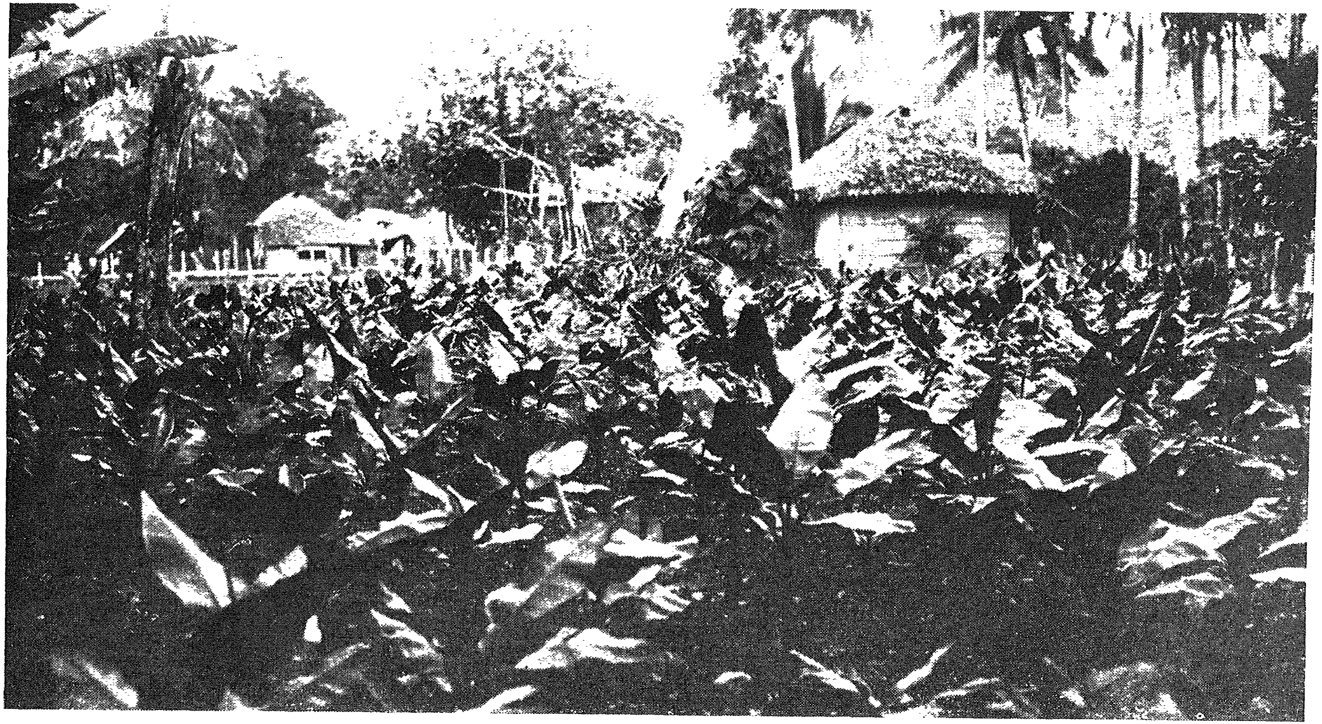

PLATE 4.

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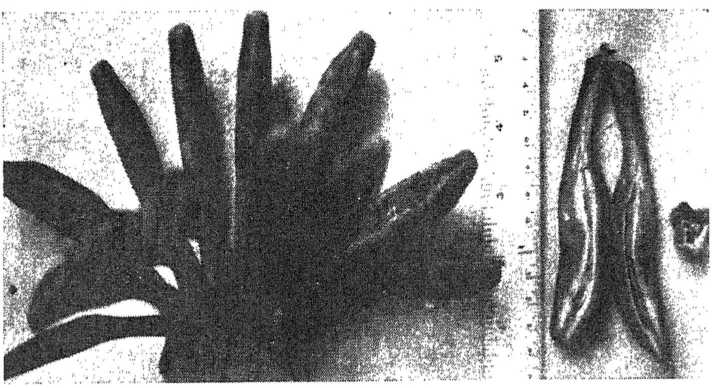

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PLATE 5.

RESULTS OF SISAL AND MAGUEY HYBRIDIZATION

By TIBURCIO G. GARRIDO [a]
Of the Bureau of Plant Industry

THREE PLATES

Sisal, *Agave sisalana* Per., was introduced into the Philippines by the defunct Bureau of Agriculture in 1905 from Hawaii. It is commercially grown in Java, East Africa, India, and the Bahamas. Maguey, *Agave cantala* Roxb., on the other hand, was probably introduced into the Philippines by the Spaniards from Mexico and it has been grown here on a commercial scale since the early part of the nineteenth century. It is commercially grown also in Java and British India(1).

Since maguey, *A. cantala* Roxb., is one of the oldest fiber crops commercially grown in the Philippines, it is entitled to receive as much attention, in its improvement through hybridization followed by selection, as many other crops. Sisal, *A. sisalana* Per., has been introduced into the Islands some thirty-four years ago for experimental purposes. Each of these species of *Agave* possesses a number of desirable characteristics which should be combined through hybridization in order to create a superior variety.

So far, only two articles on *Agave* species are worthy of note as regards breeding. These are the work of Vidal(3) in Mayaguez, Porto Rico, and that of Doughty(4) on the study of chromosome behavior in relation to the genetics of *Agave*, at Cambridge, England.

This paper presents the technique and the results so far obtained from the hybridization of the two species of *Agave*, sisal and maguey and its reciprocal. Emphasis was given to the tensile strength and elasticity of the fiber from the parents

[a] The writer acknowledges his gratitude to Dr. Juan P. Torres, Chief, Plant Breeding Section for valuable suggestions during the progress of the work and help in the preparation of the manuscript; to Dr. Vicente C. Aldaba, formerly Chief of the Fiber Research Section for encouragement during the initial stage of the work; and to Mr. M. E. Gutierrez, agronomist, for going over the final copy of the manuscript.

and that from the first generation hybrid. For, according to Matthews(2), the tensile strength and elasticity are important properties of a textile fiber. Lack of these properties would make the fiber and its resulting products brittle and unyielding, thus, greatly limiting its field of usefulness in the manufacture of cordage.

REVIEW OF LITERATURE

In the Philippines, so far as the author is aware, no breeding work on *Agave* has been conducted previous to the work reported in the following pages. Dario(5) described at length the maguey industry in Ilocos Norte and Cruz(1) described four different species of commercial *Agave* and one ornamental type, compared their production and concluded that, of the five species studied, the ornamental type included, the maguey and sisal are the best two species from the commercial standpoint.

Vidal(3) made reciprocal crosses between sisal and henequen, *Agave fourcroydes* Lem., at Mayaguez, Porto Rico, and obtained negative results when sisal was used as the pistillate parent. In the cross of henequen × sisal, he obtained only 14 crossed seed pods from 300 cross-pollinated flowers. He also claimed that in Mayaguez the sisal produces only bulbils and never seed pods in its normal condition. On the other hand, Doughty(4) found out that *Agave* species were partially fertile and *A. sisalana* was so under certain conditions favoring effective pollination.

Jones(6) states that crossing somewhat different but related species of plants or animals usually results in a greater growth, manifested in the increase in size and sturdiness of the offspring. This condition is generally known as hybrid vigor or heterosis. He further states that the individual resulting from a cross is frequently stronger, grows larger, and is more resistant to unfavorable conditions. Jones et al.,(7) mentioned the fact that hybrid vigor is a temporary manifestation which ordinarily cannot be fixed and made permanent in sexually reproduced offspring. In this connection, Gutierrez(8) believes that continuous propagation of F_1 hybrid seedlings reproduced asexually will remain always in the first generation hybrids exhibiting the desirable hybrid vigor.

MATERIALS AND METHODS

The materials used in this hybridization work were the sisal, *Agave sisalana*, Per., and maguey, *Agave cantala* which were

grown in Lamao Horticultural Station, Limay, Bataan. Sisal has green, wide, and rigid leaves without marginal spines but with sharp pointed terminal spines. It produces white, coarse, and strong fibers. Maguey has grayish green, narrow, long and wavy leaves with sharp marginal and terminal spines. It produces white, fine, and long fibers, which are weaker in tensile strength than those of the former.

Flowers.—The flowers are large (fig. 1, plate 1). The six stamens may be easily removed by means of a forcep and the stigma is easily accessible (fig. 3, plate 1). The pollen grains are produced in abundance. The large sized flowerets and their suitable arrangement made hybridization work relatively easy.

Technique in hybridization.—The inflorescence stalks of both sisal and maguey are from 5 to 10 meters high. In order to insure successful operation in the making of crosses, a strong bamboo scaffold was built around the selected pistillate flower stalk. With the use of scaffold, the position, arrangement and the right stage of the flower cluster (fig. 1, plate 1) for emasculation had been determined at close range and this greatly facilitated the work(3).

Agave plants produce numerous flowerets so that it was easy to cross 500 flowers of sisal with maguey pollen and 500 of the reciprocal cross, that is, maguey $\times$ sisal. Emasculation was performed some 4 to 5 days before the flowers burst to send off the coil filaments holding the anther (fig. 2, plate 1), thus preventing the contamination of the stigmas by their own pollen grains. After emasculation (fig. 3, plate 1), the flowers were immediately bagged and four to five days thereafter the stigmas were well out and had become glossy due to the presence of a stigmatic fluid, indicating their receptiveness for the pollen grains. The pollen grains from the male flowers were then thoroughly dusted on the stigma. It was observed that the unpollinated stigma remained normal in appearance in 5 to 6 days more before it withered.

Cross pollination was started in January, 1932. After cross pollination the crossed flowers were covered again with bags and remained in such a condition until the pods became mature enough to be harvested. All the matured pods were harvested about the end of April, 1932, or four months after crossing. All the pods were broken into pieces in order to search for viable crossed seeds.

Growing of F_1 seeds.—The 12 seeds obtained from the crossed pods of the F_1 sisal $\times$ maguey were grown in pots at the

former Plant Pathology Laboratory, Pandacan, Manila. The soil was sterilized thoroughly by steaming in a petroleum can before placing it in the pots.

The seed was brownish white, more or less round and small, about one-half the size of a mongo seed. The pot was placed in a basin containing water to keep the soil in a saturated condition and a cheesecloth cover was placed so as to prevent the access of ants and other insects which might carry away or destroy the seeds.

Barely a month after sowing, four out of the 12 seeds germinated. The four tiny seedlings were attended to with utmost care. Despite precautions, however, three of the plantlets met natural death. Only one survived and continued to grow.

The leaves of the F_1 hybrid seedlings are of intermediate type, light green in color and are as rigid as those of sisal although some of the lower leaves are flapping down like those of maguey. Unlike the sisal, the leaves of the hybrids are not entirely devoid of marginal spines (figs. 1 and 2, plate 2). For brevity the lone F_1 sisal × maguey hybrid will be called F_1 Simag.[b]

In order to make a direct phenotypic comparison between the hybrid and its parents in their performance, some bulbils were also taken from each of the two parent plants and planted in pots; thus, the F_1 Simag hybrid seedling, and the sister bulbils obtained from the same mother plants were of about the same age. It must be stated that the bulbils are asexually reproduced from the rakishes of the long pole of the inflorescence.

Transplanting Simag hybrid and its parents.—When the Plant Pathology Laboratory at Pandacan, Manila, was closed about the middle of 1933, the potted Simag hybrid and parent seedlings were transferred in pots to the Central Experiment Station at Singalong, Manila. At 14 months of age, these seedlings were about 10 inches tall. They were then transplanted permanently along the fence one meter apart on the northern side of the Central Experiment Station. The hybrid and parent seedlings were thus given the same amount of care in watering, cultivation, and treatment, with practically the same soil and climatic conditions.

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[b] "Simag" is a short name for the sisal × maguey hybrid.

Characters studied.—About the end of 1937 ($4\frac{1}{2}$ years from the date of transplanting) the leaves of both parents and hybrid were harvested and studied for: (1) the number, length, and weight of leaves; (2) the width of the leaves at the base, middle, and tip; (3) the percentage of clean dry fiber of the lower, middle, and upper leaves; and (4) the tensile strength and elasticity of the fiber.

The number of leaves represents the quantity of matured leaves comprising the harvest for the first year since this crop is usually harvested only once a year(5).

The length was determined from the base of the leaves to the base of the terminal "needle." The weights were taken immediately after harvesting the leaves, and the percentage of clean fiber was determined by the dry weight of clean fiber times 100 and divided by the weight of fresh leaves used in retting. The width of the base and tip were taken from the points two inches above the cut and two inches below the needle, respectively, and that of the center was taken from the widest portion, usually at the middle of the leaves.

Classification and retting of leaves.—Before harvesting F_1 Simag hybrid and the parent plants the three regional sections were first determined, to wit: (1) the lower or flapping leaves which formed an angle of 45° to 90° to the unfolded leaves; (2) the middle leaves which formed an angle of 30° to 45° to the unfolded leaves; and (3) the upper leaves which formed 0° to 30° to the unfolded leaves. The object of this regional leaf classification was to determine which class of leaves would give the largest percentage of retted clean fiber. The leaves were retted in a hole dug in the ground with water kept fresh all the time during the process.

Determination of tensile strength and elasticity of fibers.—The tensile strength and elasticity of the fiber were determined by means of a Louis Schopper tensile strength machine. The length of the fiber used was $\frac{1}{3}$ meter. The formula employed in determining the tensile strength follows:

$$\frac{\text{Breaking strength in kilogram}}{\text{Weight of strand} \times 3} = \text{the tensile strength per gram-meter.}$$

The elasticity of the fiber was obtained by watching carefully the pointer move up the scale until the rupture of the fiber took place; the distance covered by the pointer represented the actual

stretch or the percentage of elasticity of the fiber as described by Matthews(2). The tests for tensile strength and elasticity were performed after the fiber had been uniformly dried under room temperature after about six months from the date of retting. In sampling the materials for the above determination, 16 trials were obtained from the class 1 or lower fiber, 18 trials from the class 2 or middle fiber and 16 trials from the class 3 or upper fiber, from the hybrid and parents, or 50 trials in every case, making a total of 150 trials in all. Thus, the above samples represented homogeneously the strength and elasticity of the fiber obtained from the different classes of leaves of each of the plants studied.

RESULTS

Out of the 500 flowers of sisal crossed with maguey only 12 or 2.4 per cent formed matured pods, each producing a seed. The percentage of successfully crossed pods was indeed very low. This result seems to confirm Doughty's(4) observation on sisal which, according to him, becomes partially fertile under certain conditions, but the negative results obtained by Vidal(3) when he used sisal as female parent and henequen as male parent may be attributed either to the less number of flowers employed or to the unfavorable conditions at the time of crossing.

All the results obtained are given in frequency distribution table Nos. 1 to 7, inclusive, which in turn were summarized in the last two tables, Nos. 8 and 9.

The F_1 Simag hybrid assumes an intermediate type between its two parents. It possesses some of the marginal prickles, the medium grayish green color of the leaves, the length and the flapping habit of the lower leaves of the maguey male parent and because of its vigorous condition, perhaps due to heterosis, its leaves are on the average wider and heavier than those of either parent.

Length of leaves.—It can be seen in table 9 that the leaves of maguey are longer than those of sisal with a significant difference of 6.15 ± 1.53 centimeters. The Simag, however, has a mean length greater by 5.58 ± 1.20 and 0.57 ± 1.12 centimeters than those of sisal and maguey, respectively. Apparently, it is significantly longer than sisal but nearly as long as maguey.

TABLE 1.—*Frequency distribution for the length of leaves of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value in centimeters										Total
	80	84.1	88.2	92.3	96.4	100.5	104.6	108.7	112.8	116.9	
Sisal	2		1	1	8	5	7	1			25
Maguey				1	6	7	2	2	2	5	25
F_1 Simag				2	3	3	7	10			25

M[1]	S. D.[2]	C. V.[3]
98.20±0.96	7.12±0.68	7.25±0.69
104.35±1.22	9.04±0.86	8.66±0.83
103.78±0.72	5.32±0.51	5.12±0.49

NOTE: [1] Mean. [2] Standard deviation. [3] Coefficient of variability.

TABLE 2.—*Frequency distribution for the width at the base of leaves of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value in centimeters										Total
	3	3.4	3.8	4.2	4.6	5.0	5.4	5.8	6.2	6.6	
Sisal					1	10	13	1			25
Maguey	5	16	4								25
F_1 Simag								4	18	3	25

M	S. D.	C. V.
5.22±0.05	0.35±0.03	6.65±0.63
3.38±0.04	0.30±0.03	8.87±0.85
6.18±0.04	0.32±0.03	5.11±0.49

TABLE 3.—*Frequency distribution for the width at the middle of leaves of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value in centimeters										Total
	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	
Sisal					2	1	3	8	5	6	25
Maguey	10	4	5	6							25
F_1 Simag								3	5	17	25

M	S. D.	C. V.
9.62±0.10	0.73±0.06	7.57±0.74
6.64±0.08	0.61±0.06	9.16±0.89
10.28±0.05	0.35±0.03	3.37±0.32

TABLE 4.—*Frequency distribution for the top width of leaves of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value in centimeters									Total
	3.0	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	
Sisal				5	9	8	1	1	1	25
Maguey	2		1	6	8	4	3	1		25
F_1 Simag			1	9	9	1	3		2	25

M	S. D.	C. V.
4.34±0.05	0.40±0.04	9.22±0.89
4.16±0.07	0.52±0.05	12.50±1.22
4.25±0.04	0.44±0.04	10.26±0.99

TABLE 5.—*Frequency distribution for the weight of leaves of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value in grams										Total
	137.0	177.1	217.2	257.3	297.4	337.5	377.6	417.7	457.8	497.9	
Sisal			1	4	4	15	1				25
Maguey	10	14	1								25
F_1 Simag							4	1	15	5	25

M	S. D.	C. V.
315.04±5.08	37.69±3.59	11.96±1.16
162.66±3.04	22.36±2.13	13.75±1.32
451.38±5.00	37.06±7.07	16.25±1.60

TABLE 6.—*Frequency distribution for the tensile strength of the fiber of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value per gram-meter in kilogram										Total
	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	
Sisal	2	2	6	9	6	10	3	7	3	2	50
Maguey	13	13	11	8	5						50
F_1 Simag	2	3	8	10	8	9	1	5		4	50

M	S. D.	C. V.
17.22±0.32	3.38±0.23	19.63±1.36
12.87±0.19	1.95±0.13	15.15±1.05
16.59±0.33	3.41±0.23	20.55±1.40

Basal, middle, and top widths of leaves.—A study of the data for basal widths as shown in table 9 will show that sisal has a wider base than maguey by 1.84 ± 0.06 centimeters but as compared with the Simag the mean differences are 0.96 ± 0.07 and 2.80 ± 0.06 centimeters over sisal and maguey, respectively.

With regard to middle width, shown in table 9, that of sisal is greater than that of maguey by 2.98 ± 0.13 centimeters. The mean basal width of 10.26 ± 0.05 centimeters of the Simag is greater than those of sisal and maguey by 0.66 ± 0.11 and 3.62 ± 0.09 centimeters, respectively. Hence the leaves of the Simag are significantly wider than those of either parent. As to the top widths of the leaves as shown in table 4, there are insignificant differences.

Weight of leaves.—There is a wide margin between the mean weights of fresh leaves of the parent varieties (table 5) as sisal gave 315.04 ± 5.08 grams and maguey, 162 ±3.04 grams, or a difference of 152.38 ± 5.92 grams. However, the Simag with a mean weight of 451.38 ± 5.00 grams has heavier leaves with mean differences of 116.34 ± 11.12 and 268.72 ± 10.34 grams over sisal and maguey, respectively. These differences are significantly large perhaps due to increase in size and weight as influenced by heterosis.

In this particular character the standard deviations are quite large, being 37.69 ± 3.59 grams for sisal, 22.36 ± 2.13 grams for maguey, and 37.06 ± 7.07 grams for the F_1 Simag with coefficients of variability of 11.96 ± 1.16, 13.75 ± 1.32 and 16.25 ± 1.60 per cent, respectively. These high coefficients of variability indicate that the materials used with respect to this character are not uniform and, therefore, the data indicate that 25 trials in every case are not sufficient. Nevertheless the differences in the means as pointed out are undoubtedly statistically significant.

Tensile strength and elasticity.—It has been stated that in the breeding experiment of fiber plants, emphasis is on the tensile strength and on the elasticity of the fiber produced. Upon these two characters mainly depends the usefulness of the fiber and consequently the durability and quality of the articles made from it. In table 6 it can be seen that the mean tensile strength of sisal is 17.22 ± 0.32 kilograms and that of maguey, 12.87 ± 0.19 kilograms, hence a difference of 4.35 ± 0.32 kilograms in favor of sisal, indicating that sisal fiber is significantly stronger than that of maguey. Compared with the F_1 Simag hybrid

having a tensile strength of 16.59 ± 0.33 kilograms the differences are 0.63 ± 0.45 and 3.72 ± 0.38 kilograms showing that the hybrid is nearly as strong as sisal but significantly stronger than maguey. The coefficient of variability of sisal is 19.63 ± 1.36 kilograms and that of maguey, 15.15 ± 1.05 kilograms. Hence, the coefficient of variability of the tensile strength of sisal fiber is greater by 4.48 ± 1.36 per cent than that of maguey, showing that there is a wider variation in sisal fiber than in that of maguey. The F_1 Simag with a deviation of 3.41 ± 0.23 kilogram and a coefficient of variability of 20.55 per cent has, therefore, the widest variation in tensile strength, although statistically it is almost as variable in its tensile strength as sisal fiber.

The elasticity.—Table 7 shows the elasticity of the fiber of the parents and their hybrid. Sisal gave 1.78 ± 0.05 per cent elasticity of fiber; maguey, 1.57 ± 0.04 per cent, or a difference of 0.21 ± 0.01 per cent, which is hardly significant. The mean difference between Simag, with an elasticity of 1.79 ± 0.04 per cent and sisal, is 0.01 ± 0.06 per cent; between Simag and maguey, 0.22 ± 0.06 per cent. The fiber of the F_1 Simag, therefore, is as pliable or elastic as that of sisal and slightly more so than that of maguey.

With respect to the coefficient of variability of elasticity of the fiber it is apparent that the parents as well as the resulting hybrid are almost equally variable but if the standard error is taken as the basis of measuring the significance of the results obtained as commonly used by some European workers(9), it is obvious that the pliability or elasticity of the F_1 Simag fiber depends on the syzygetic combination of the qualities of the parents.

Percentage of fiber.—The percentage of fiber in the three classes of leaves in sisal, maguey, and Simag hybrid taken as a whole, tends to increase, from the lower to the upper leaves. However, the increases or mean differences between regional classes of leaves as shown in table 8, are not at all statistically significant. Considering the mean percentages of fiber for each variety studied (table 8, column 10) and comparing them with each other, the differences are also insignificant.

It must be stated in this connection that the data presented are meager due to the very limited amount of materials available for study. However, this point will be more critically studied as soon as sufficient materials become available.

Yield of fiber.—The total yield for the first year harvest of a single plant was determined. The maguey plant produced the least amount of fiber, 172.0 grams, the sisal next, 274.3 grams, and the F_1 Simag gave 419.6 grams of clean fiber. Indeed, not much weight can be placed upon the yield data of a single plant. Nevertheless their relative value may be considered for reference and record purposes as the work is still in progress. Like the percentage of fiber, the yield will be more conclusively studied whenever practicable or as soon as sufficient materials shall have been produced.

TABLE 7.—*Frequency distribution for the elasticity of the fiber of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value in per cent										Total	M	S. D.	C. V.
	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0				
Sisal	9	7	10	8	5	2	4	2	1	2	50	1.78±0.05	0.49±0.03	27.53±1.99
Maguey	14	13	6	4	5	3	3	2	------	------	50	1.57±0 04	0.40±0.03	25.48±1.82
F_1 Simag	8	9	7	6	8	5	3	2	1	1	50	1.79±0.04	0.46±0.03	25.71±1.84

TABLE 8.—*Fiber content of class 1, lower; class 2, middle; and class 3, upper leaves of the F_1 Simag hybrid and its parent varieties.*

Variety	Class 1			Class 2		
	Weight fresh (gms)	Clean weight (gms)	Fiber per cent	Weight fresh (gms)	Clean weight (gms)	Fiber per cent
Sisal	1,813	56.8	3.2	3.430	110.0	3.2
Maguey	1,484	51.3	3.4	1,480	53.0	3.6
F_1 Simag	3,542	118.0	3.3	3,815	132.4	3.5

Variety	Class 3			Mean of classes per cent	Total yield clean fiber (gms)
	Weight fresh (gms)	Clean weight (gms)	Fiber per cent		
Sisal	3 149	107.5	3.4	3.27±0.06	274.3
Maguey	1 644	67.7	4.1	3.70±0.20	172.0
F_1 Simag	4.341	169.2	3.9	3.57±0.17	419.6

Mean per cent of fiber for each class .... 3.30 ± 0.05 3.40 ± 0.12 3.80 ± 0.20

GENERAL DISCUSSION

A study of the data presented in table 9 will show that the two parent varieties differ greatly from each other in the characters studied. Sisal has shorter but wider leaves at the base and at the middle, heavier leaves and stronger fiber than maguey. As compared with sisal, the F_1 Simag hybrid possesses longer and slightly wider leaves at the base and at the middle and heavier leaves, but is almost equal to sisal as regards tensile strength and elasticity of the fiber. Compared with maguey, the leaves of the F_1 Simag hybrid are almost as long but are significantly wider at the base and at the middle and are much heavier, and its fiber is decidedly stronger and slightly more elastic. As regards top-widths of the leaves and percentage of fiber, Simag, sisal, and maguey are practically the same as the mean differences for these characters are very insignificant.

TABLE. 9.—*Summary of tables 1 to 7 inclusive comparing the means of the F_1 Simag, Agave hybrid with its parents, sisal (A. sisalana Per.) and maguey (A. cantala Roxb.)*

Characters	Sisal	Maguey	Difference between sisal and maguey	F_1 Simag
Mean length of leaves (cm.)	98.20 ±0.96	104.35 ±1.22	6.15 ±1.53	103.78 ±0.72
Mean basal width of leaves (cm.)	5.22 ±0.05	3.38 ±0.04	1.84 ±0.06	6.18 ±0.04
Mean middle width of leaves (cm.)	9.62 ±0.10	6.64 ±0.08	2.98 ±0.13	10.28 ±0.05
Mean top width of leaves (cm.)	4.34 ±0.05	4.16 ±0.07	0.18 ±0.09	4.25 ±0.04
Mean weight of fresh leaves (gms.)	315.04 ±5.08	162.66 ±3.04	152.38 ±5.92	451.38 ±5.00
Mean tensile strength of fiber (kgs.)	17.22 ±0.32	12.87 ±0.19	4.35 ±0.32	16.59 ±0.33
Mean elasticity of fiber (per cent)	1.78 ±0.05	1.57 ±0.04	0.21 ±0.06	1.79 ±0.04
Mean percentage of fiber from 3 classes	3.27 ±0.06	3.70 ±0.20	0.43 ±0.21	3.57 ±0.17

Characters	Difference (+ or −)		Increase over average of parents (per cent)
	Over sisal	Over maguey	
Mean length of leaves (cm.)	+ 5.58 ± 1.20	− 0.57 ± 1.12	2.5
Mean basal width of leaves (cm.)	+ 0.96 ± 0.07	+ 2.80 ± 0.06	43.7
Mean middle width of leaves (cm.)	+ 0.66 ± 0.11	+ 3.62 ± 0.09	26.4
Mean top width of leaves (cm.)	− 0.09 ± 0.07	+ 0.09 ± 0.07	0.0
Mean weight of fresh leaves (gms.)	+116.34 ±11.12	+268.72 ±10.34	88.9
Mean tensile strength of fiber (kgs.)	− 0.63 ± 0.45	+ 3.72 ± 0.38	10.2
Mean elasticity of fiber (per cent)	+ 0.01 ± 0.06	+ 0.22 ± 0.06	7.2
Mean percentage of fiber from 3 classes	+ 0.30 ± 0.54	− 0.13 ± 0.26	2.6

Comparing the average measurement of characters of the leaves of the two parent varieties and the F_1 Simag hybrid (table 9, column 7), excepting the top-width, the hybrid is either slightly or decidedly greater. It is 2.5 per cent longer, 43.7 per cent wider at the base, 26.4 per cent wider at the middle, 88.9 per cent heavier; and its fiber is 10.2 per cent greater in tensile strength, 7.2 per cent, in elasticity and 2.6 in mean percentage of fiber.

Propagation of the F_1 Simag.—As it usually takes about 6 to 7 years before sisal and maguey produce flowers and bulbils, it is expected that the resultant hybrid may produce bulbils after nearly as long a period. The propagation of the F_1 Simag hybrid is therefore limited to the production of suckers and rhizomes. Unfortunately, the lone F_1 Simag suffered from last year's flood which caused its natural death, but it had produced some 9 living suckers. Seven of them, together with some sisal and maguey suckers, were planted at the beginning of the rainy season of 1938 at the Commonwealth Farm, Muntinlupa, Rizal. These F_1 Simag suckers are given excellent care and all possible efforts will be exerted so as to multiply them as rapidly as possible.

At the present writing, the F_1 suckers on the Commonwealth Farm have just been observed to be growing very thriftily and evidently show the effect of hybrid vigor or heterosis as they appear far more vigorous than the suckers of the parent varieties that were planted at the same time. Such pronounced vigor of the F_1 suckers is to be expected because by asexual propagation, i.e., by planting suckers, rhizomes, and bulbils, the hybrid materials will always remain as hybrids exhibiting heterosis[8] unless altered by an unusual somatic mutation which, of course, very seldom occurs under normal conditions.

SUMMARY

Out of 500 sisal flowers crossed with maguey pollen only 12 seed-pods were produced, and not one seed-pod developed from 500 maguey flowers cross-pollinated with sisal pollen. These results indicate that crossing them is possible only in one direction because maguey does not produce seed-pod even though it produces abundant pollen grains. These results, therefore, confirmed the findings of Doughty[4] which showed that *A. sisalana* was partially fertile under certain conditions favoring effective pollination.

From the 12 crossed seeds produced, only 4 germinated and out of this number only one plantlet survived and continued to grow and gave nine F_1 suckers.

The F_1 hybrid, which is now named "Simag," a name derived from the contracted first syllables of the parent varieties, appeared more vigorous than either parent, an apparent effect of heterosis. It assumes a form intermediate between the two parents. It possesses some of the marginal prickles, waviness, flapping of mature leaves, the grayish green color and the length of leaves of the maguey male parent, and it also inherited from the sisal female parent the broad basal and middle portions of the leaves. The leaves are about intermediate in thickness.

The fiber of the F_1 Simag is decidedly stronger and slightly more elastic than that of maguey but is almost at par with that of sisal. In percentage of fiber, the three classes of leaves, the lower, the middle, and the upper are practically the same with slight tendency to decrease as the leaves become older. It may be stated that the F_1 Simag, sisal and maguey are practically the same as regards percentage of fiber. Nevertheless the meager data show somewhat greater amount of fiber produced by the F_1 Simag as compared with the two parent varieties.

The tensile strength, the yields, and the percentage of fiber should be further studied as soon as sufficient materials become available.

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ILUSTRATIONS

PLATE 1

FIG. 1. The flower cluster: (*a*) matured flowers almost ready to dehisce their pollen; (*b*) the right stage of the floweret for emasculation; and (c) young flowerets.

2. A floweret which was broken by forceps for emasculation before it burst to send off the coil filaments holding the anther.

3. Emasculated floweret ready for pollination.

PLATE 2

FIG. 1. *Left*, the pistillate parent, sisal, *Agave sisalana*. Note the dark green, wide, and rigid leaves. *Right*, the staminate parent, maguey, *Agave cantala*. Note the flappy, grayish-green, narrow and long leaves. *Center*, the first generation Simag hybrid. Note the size of the plant which exhibits hybrid vigor. The wide leaves are intermediate light green and are as rigid as those of sisal although some of the lower leaves are flapping like those of maguey.

2. (1) Sisal leaf without marginal spines. (2) First generation Simag hybrid leaf, not entirely devoid of marginal spines. (3) Maguey leaf with pronounced marginal spines.

PLATE 3

THE FIBERS

The first three at the left are fibers of sisal; the three at the right, those of maguey; the three at the middle, F_1 Simag. Numbers 1, 2, and 3 represent the fibers obtained from the lower, middle, and upper leaves, respectively.

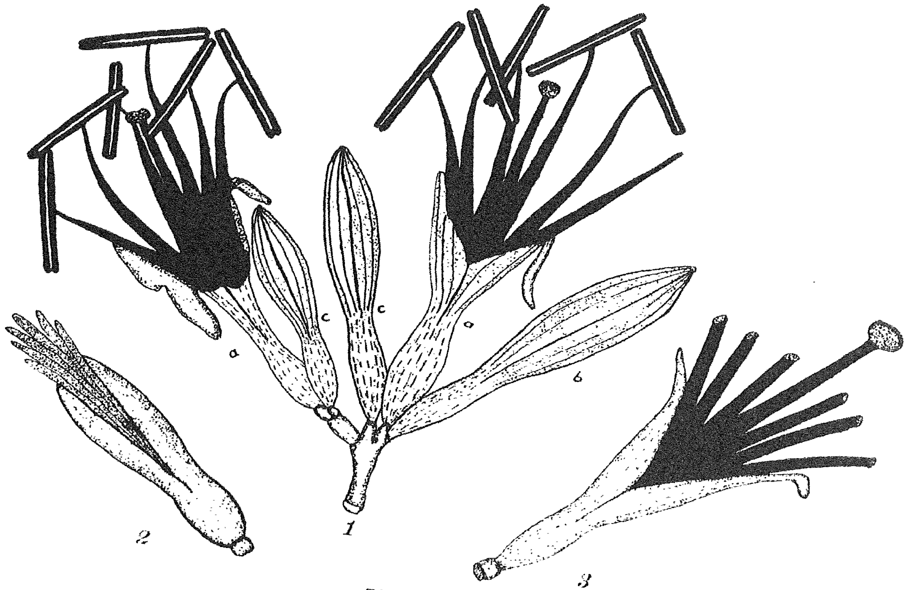
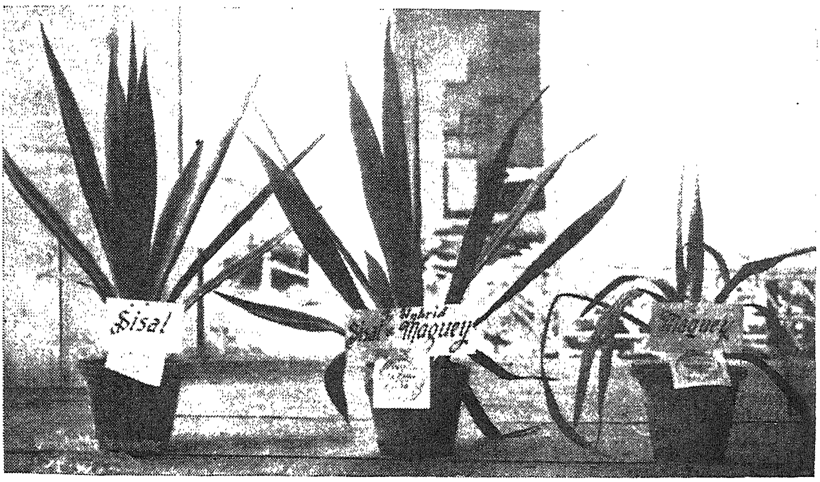


PLATE 1.



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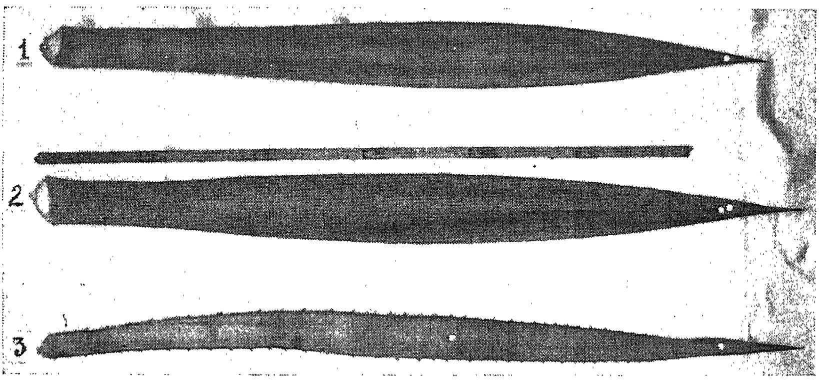

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PLATE 2.

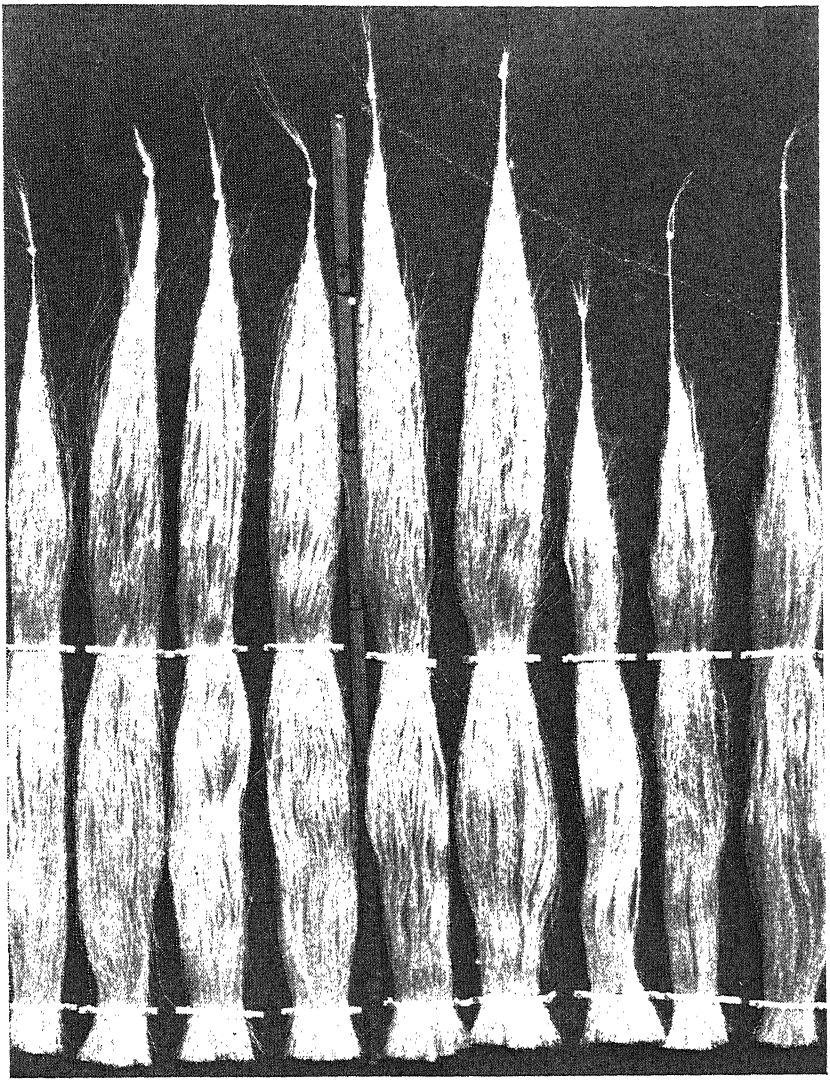

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PLATE 3.

PLANT EXPLORATION AND INTRODUCTION WORK OF THE BUREAU OF PLANT INDUSTRY

By M. MANAS Y CRUZ, *In Charge, Seed and Plant Introduction*
FERNANDO DE LOS REYES, *Assistant Agronomist*
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In an eminently agricultural country like the Philippines, the importance of plant exploration and introduction is self-evident. While the former concerns with the search for wild species of economic value for domestication purposes, the latter deals principally with the introduction of foreign plants of desirable qualities with the end in view of improving our cultivated crops. Thus, the little known regions of Mindanao and other sections of these Islands must be explored for humidity-loving plants; the Mountain Province, for subtropical species, etc. Moreover, plants of known economic value need to be introduced from abroad for acclimatization, propagation, and hybridization, if necessary. This short-cut method of improving our cultivated crop varieties and increasing the wealth and resources of our flora was started by the old Bureau of Agriculture in 1902 and carried on to the present time by the Bureau of Plant Industry.

Much of our seed and plant introduction work had been done by the personnel of the former Bureau of Agriculture, to wit: Mr. O. W. Barrett, who was responsible for the introduction of a big collection of bananas from the British East Indies, India and China, in 1911–1913; Mr. H. H. Boyle, who introduced the Siamese seedless pummelo from Siam, in 1912; the late Secretary Silverio P. Apostol, who introduced varieties of rice from Italy, Java, Japan, China and India, in 1919–1921; Mr. Domingo B. Paguirigan, who introduced varieties of tobacco from Sumatra, in 1925–1927; Mr. Francisco G. Galang, who introduced certain selected clones of Para rubber from Sumatra, in 1926; Prof. Harold Cuzner, who in 1904 made the first introduction of avocados in the forest reservation of the Government at Lamao, Bataan; and the late P. J. Wester, who devoted the best years of his life to plant introduction and exploration activities in these Islands and whose salient accomplishments are embodied

in Bulletin No. 39, entitled "The Food Plants of the Philippines." Besides, numerous species of exotic plants had also been introduced by the College of Agriculture, University of the Philippines, the Bureau of Forestry and the City Nurseries of Manila and Baguio.

In our introduction work, seed and plant materials are secured either through exchange with foreign experiment stations, public parks, government entities and private individuals, or by purchase from seed farms and nurseries abroad.

Up to 1937, the following introductions have been made:

Total number of species	953
Total number of varieties	7,049
Countries of origin	47

Directly traceable to the plant introduction work of the Bureau of Plant Industry, is the fact that at present we are successfully growing in these Islands a big number of such plant immigrants as citrus, avocado, caimito, tiessa, strawberry, onions, cabbages, cauliflower, tobacco, Para rubber, etc.

The following is the first part of an inventory of seed and plant introductions made by the Bureau of Plant Industry which will be published in series:

SUGAR CANE, *Saccharum officinarum* L. (GRAMINEAE)

P. I. No. 4910: P. O. J. 2878.—Introduced from Java through Dr. Bach in 1927. This is a well-known hybrid cane from Java, which occupies a considerable portion of our sugar-cane lands today. Its desirable qualities are heavy yield, good growth even on low heavy soils, and large, vigorous suckers. Undesirable qualities include juice of low purity, long growing period, slow ratoon growth, heavy tasseling, coming early in season with consequent pithy stalks, and inability to withstand winds. It is highly susceptible to the stem borer. This variety of cane should be planted early and harvested in 14 months. Yield per hectare: 71.30 tons of cane equivalent to 103.51 piculs of sugar. Grown by the Agricultural Service, Inc., La Granja, Occidental Negros (formerly La Granja Sugar Cane Experiment Station, Bureau of Plant Industry).

P. I. No. 8743: Badila.—Introduced from Australia in 1913. First grown in the La Carlota Sugar Cane Experiment Station, La Carlota, Occidental Negros. The Badila is a stout purple cane which grows erect and matures in 12 to 14 months after planting. Its sugar content is high. It grows best in fertile soils, either upland or lowland, and gives particularly good yield

when planted from September to December. Yield per hectare: 67.89 tons of cane equivalent to 132.57 piculs of sugar (sucrose, over 18 per cent, and 90 per cent juice purity). Being grown by the Agricultural Service, Inc., La Granja, Occidental Negros (formerly La Granja Sugar Cane Experiment Station, Bureau of Plant Industry.)

P. I. No. 9374: Mauritius—1900.—Received from Pampanga Sugar Mills, Del Carmen, Pampanga in 1926. Sent to the La Carlota Sugar Cane Experiment Station, La Carlota, Occidental Negros. This variety has acquired some degree of importance in Luzon where it is grown on all kinds of soils. On sandy and poor clay soils it grows erect and stools slightly but may suffer from extreme droughts. On fertile soils or good clay loams, the cane may be prostrate, but the yield is heavy. The color varies according to the amount of exposure, from faint reddish violet to deep violet. Growth is easily affected by drought, disease and insect pests. Yield per hectare: 59.45 tons of cane equivalent to 102.34 piculs of sugar. Being grown by the Agricultural Service Inc., La Granja, Occidental Negros (formerly La Granja Sugar Cane Experiment Station, Bureau of Plant Industry, La Granja, Occidental Negros).

P. I. No. 10365: Barbados 147.—Introduced from Buitenzorg, Java, in 1919. This is a yellow medium-sized cane with a propensity to recline when nearly mature. It grows well in poor soil and is able to resist mosaic and Fiji diseases. It matures in 12 to 14 months. Suitable for small mills on account of its size and soft tissue. A good chewing cane. Yield per hectare: 81.41 tons of cane equivalent to 134.34 piculs of sugar. Formerly grown at the La Carlota Sugar Cane Experiment Station, La Carlota, Occidental Negros.

P. I. No. 10366: D. I. 52.—Introduced from Proefstation, Pasoeroean, Java, in 1919. Sent to the La Carlota Sugar Cane Experiment Station, La Carlota, Occidental Negros. It is an early variety well adapted to grinding in small mills for the production of muscovado sugar. It can be harvested in 10 months when planted early, as in October or November. The cane is purplish and is erect in growth. It is good for chewing purposes. Yield per hectare: 68.77 tons of cane equivalent to 129.64 piculs of sugar.

P. I. No. 10381: P. S. A. 14.—From the Philippine Sugar Association, Manila. Received in 1931 and sent to the La Granja Sugar Cane Experiment Station, La Granja, Occidental Negros. This is a cross between PB–119 and CAC–82. The

cane matures early, is erect, and is greenish purple. It is hardy against wind and is practically immune to diseases. The sugar content is high. In recent years (1934–1935), this variety yielded more sugar than any other variety in Luzon. Yield per hectare: 68.15 tons of cane equivalent to 134.94 piculs of sugar. Being grown by the Lipa Coffee–Citrus Station and the Agricultural Service, Inc. (formerly La Granja Sugar Cane Experiment Station, Bureau of Plant Industry).

P. I. No. 10382: Alunan cane (*L. C. 25/191*).—This is a cross developed by the Bureau between the Badila and the Java 247. It gives heavy yields of sugar in the soils of central Occidental Negros, where in 1936, approximately one-fifth of the total cane areas was planted to it. It grows rapidly and matures in about 12 months. Half-matured stalks may be cut and planted in the months of September and October. Yield per hectare: 90.80 tons of cane equivalent to 180.04 piculs of sugar. Being grown by the Agricultural Service, Inc., La Granja, Occidental Negros (formerly La Granja Sugar Cane Experiment Station, Bureau of Plant Industry).

FORAGE GRASSES (GRAMINEAE)

P. I. No. 5488: Napier grass, Pennisetum purpureum Schum.—A tall, erect, perennial, and coarse grass attaining a height of about 2.5 to 4 meters. Leaf about 70 centimeters long and 1.5 to 2 centimeters broad, hairy at the base and on both surfaces; stalk, similar to that of the Uba cane but smaller, spongy, and with a hollow stem; flower, like a cat's tail, brownish in color with very fine seeds. A native of tropical Africa, introduced from Hawaii in 1916. Yields about 93,000 kilos of green forage per hectare a year. Relished by animals when cut every twenty days. Formerly grown at the Lamao Experiment Station, Lamao, Bataan. Analysis: moisture 83.32 per cent; protein, 1.6 per cent; crude fiber, 5.64 per cent; fat, 0.59 per cent; and carbohydrates, 6.61 per cent.

P. I. No. 266: Dallis grass, Paspalum dilatatum Poir.—Introduced from Australia in 1907 and sent to the Lamao Experiment Station, Lamao, Bataan. A perennial pasture grass attaining a height of about 50 to 70 centimeters. Leaves, short and narrow, 28 centimeters long and 1.2 centimeters wide; edges, catchy; surface, smooth. Flower in head with from 3 to 4 spikelets, arranged alternately on the flower stalk. Stigma, dark purple. Yields about 26,000 kilos of green forage per

hectare a year. Relished by stock when cut every twenty days. Formerly grown at the Lamao Experiment Station, Lamao, Bataan. Analysis: moisture, 66.0 per cent; protein, 1.8 per cent; ash, 3.2 per cent; crude fiber, 26.9 per cent; fat, 0.9 per cent; and carbohydrates, 1.2 per cent.

P. I. No. 302: Cayenne grass, Unidentified sp.—Introduced from Ventimiglia, Italy, on August 29, 1914. Grown for the first time at the Singalong Experiment Station, Bureau of Agriculture, Manila. A perennial creeping grass. Roots develop from every joint that touches the ground; leaves, about 54.5 centimeters long and 2.4 centimeters broad; edges and upper surface of the leaf, rough; lower surface, smooth. Leaf sheath, purplish in color and covered with many long stiff hairs. Stalk, spongy inside; internode, from 8 to 12 centimeters long.

P. I. No. 321: Para grass, Panicum barbinode Trin.—Introduced in 1910 from Ceylon. A coarse, perennial, creeping grass attaining a height of from 1 to 2 meters under favorable conditions. Stem becomes erect when the plants are crowded. Leaf dagger-shaped with short butts; 17.5 centimeters long and 1.5 centimeters wide; edges raspy, smooth on both surfaces. Leaf sheath, covered with colorless hairs. Stalk, slender and hollow; internode, about 8.5 to 10 centimeters long. Roots are formed on every joint touching the soil and are fibrous. Flowers, spike-like racemes arranged opposite each other. In moist ground Para may even check cogon. A native of South America. It yields in one year about 29,000 kilos of green forage per hectare. Relished by stock when cut every twenty days. Grown for the first time at the Singalong Experiment Station, Bureau of Agriculture, Manila. Analysis: moisture, 70.44 per cent; protein, 1.63 per cent; fat, 0.48 per cent; ash, 1.96 per cent; and carbohydrates, 25.49 per cent.

P. I. No. 1590: Teosinte, Euchlaena mexicana Schrad.—Introduced from Sydney, Australia, in 1908. Grown for the first time at the Singalong Experiment Station, Bureau of Agriculture, Manila. This can be grown successfully and makes an excellent forage, being very succulent and a heavy yielder and producer of good seeds. It cures out more like corn. It does better at sea level than at higher altitudes, but will not stand drought. It yields 62,313 kilos of forage per hectare after 141 days. On good fertile soil and with plenty of water, teosinte will produce a heavier yield of very succulent green feed than Guinea grass.

P. I. No. 1819: Guinea grass, Panicum maximum Jacq.—A native of tropical Africa, introduced into the Philippines in 1907 from Hawaii. An erect, rather coarse, and perennial grass, about a meter or more high and with long and narrow leaves. Edges, base, and upper surface of leaves hairy, lower surface purplish and smooth. Stalk, slender and fibrous but spongy at the center. Flower in head composed of circle of spikelets formed of individual small flowers. Stigma purple. Yields about 53,000 kilos of green forage per hectare a year. Relished by animals when cut every twenty days. Formerly grown at the Lamao Experiment Station, Lamao, Bataan. Analysis: moisture, 71.5 per cent; protein, 1.2 per cent; ash, 2.2 per cent; crude fiber, 10.9 per cent; fat, 0.7 per cent; and carbohydrates, 12.1 per cent.

P. I. No. 2192: Merker grass, Pennisetum merkerii Schum.—Introduced at the Lamao Experiment Station, Lamao, Bataan, from Davao, Mindanao, in 1912. An erect, tall, perennial grass resembling Napier in all respects except that the leaves are longer and narrower and the stalk more slender, with tiny hairs about the base and fibrous tissues inside. Edges and upper surface, rough; lower surface, smooth. Flowers, brownish and borne in spikes.

P. I. No. 6933: Guatemala grass, Tripsacum laxum Nées.—A tall, erect, perennial grass very much resembling corn at a distance, except that it has short stalks. Leaves, about 90 centimeters long and 5.7 centimeters broad; raspy edges with a tinge of purple; upper surface, rough and lower, smooth; leaf sheath, pinkish to purplish; stalk, flattened and almost covered by leaf-sheath. This grass was received on April 11, 1919 from the U. S. Department of Agriculture, Washington, D. C., U. S. A. Yields about 36.500 kilos of green forage per hectare a year. Relished by animals when cut every sixty days. Grown for the first time at the Singalong Experiment Station, Bureau of Agriculture, Manila.

P. I. No. 8788: Uba cane, Saccharum officinarum L.—Collected and grown at the Lamao Experiment Station, Lamao, Bataan, in April, 1911. Grown for the first time at the La Carlota Sugar Cane Experiment Station, La Carlota, Occidental Negros. The leaf of this cane makes a good forage. Cane, slender with long narrow leaves; leaf base, hairy. Flowers, similar to those of sugar cane. Some people use this variety as a source of sugar, it being hardy and resistant to various diseases of the sugar

cane, although less juicy. It yields in one year about 56,600 kilos of green forage per hectare. Relished by stock when cut at the age of ninety days. Analysis (dry basis): moisture, 6.75 per cent; protein, 1.37 per cent; fat, 1.89 per cent; ash, 2.04 per cent; crude fiber, 26.6 per cent; and carbohydrates, 67.35 per cent.

P. I. No. 13775: Bungalon grass, Homalocenchus hexandrus Pers.—A perennial creeping native grass commonly cultivated around Manila. Leaves about 32.5 centimeters long and 1.2 centimeters broad with trichomes at the base. Base of leaf sheath which surrounds the nodes, covered with fine hairs: leaf, hairy at the edges and on upper surface, and smooth on the nether surface. Stalk grows erect when the plants become crowded; internode varies from 6.5 to 10 centimeters long; roots spring from every node that touches the ground. Internal part of the stalk has fibers like cotton threads attached to it at the center. Yields about 12,000 kilos of green forage per hectare a year. Relished by animals when cut about 90 days old. Introduced from Iloilo, Iloilo, in 1926 at the Lamao Experiment Station, Lamao, Bataan.

P. I. No. 8982: Sudan grass, Holcus halepensis L.—Introduced at the Lamao Experiment Station, Lamao, Bataan, from Washington, D. C., in 1925. A tall perennial grass with fine leafy steams, the largest stalk seldom larger than a lead pencil; panicles, loose and open and pyramidal in form. It yields approximately 20,000 kilos of green forage per hectare annually; forage or hay, slightly coarse, but quite palatable if cut or pastured on before seed formation. It makes a good soiling crop for native cattle and carabaos. Analysis (dry basis): protein, 4.43 per cent; fat, 2.92 per cent; crude fiber, 36.82 per cent; ash, 9.63 per cent; and carbohydrates, 46.2 per cent.

PEANUTS, *Arachis hypogaea* L. (LEGUMINOSAE)

P. I. No. 8304: Tennessee Red.—Introduced from New Orleans, Louisiana, U. S. A., on March 17, 1923. This variety exhibits a vigorous upright growth. The pods which form at the base of the plant are long and slender with three to four kernels of bright red color. The shell is thin. This peanut matures in from 105 to 125 days, and yields about 12 cavans of shelled nuts per hectare. This variety is generally used for roasting purposes. Formerly grown at the Lamao Experiment Station, Lamao, Bataan.

P. I. No. 10072: Virginia Runner.—Introduced from Texas, U. S. A., on March 3, 1929. This variety has a spreading habit of growth, which makes it rather hard to cultivate and to harvest. Large podded variety; strong grower; stems, creeping; foliage, heavy; pods, scattered along procumbent stems; pods and peas, very similar to those of Virginia Bunch; pods do not adhere well to the plant upon digging. It matures in from 165 to 185 days, and yields about 14 cavans of shelled nuts per hectare. Formerly grown at the Lamao Experiment Station, Lamao, Bataan.

P. I. No. 10073: Virginia Bunch.—Introduced from Texas, U. S. A., on March 1, 1929. The pods of this variety are very similar to those of Virginia Runner; plant, rather dwarf; stems, upright; foliage, rather light; pods, clustered about the base of the plant, with usually two, sometimes three kernels in a pod, bright and clean; color of kernel, light brown; pods adhere well to the plant upon digging. The crop matures in from 165 to 185 days, and yields about 12 cavans of shelled nuts per hectare. Formerly grown at the Lamao Experiment Station, Lamao, Bataan.

P. I. No. 11446: Valencia.—Introduced from Oneco, Florida, U. S. A., on February 25, 1933. Grown for the first time at the former Alabang Rice Experiment Station, Alabang, Rizal. A very promising variety from Spain; a desirable sort for the manufacture of peanut butter; also for blanched and salted peanuts. A heavy yielder, and it matures in from 165 to 185 days after date of planting. Yields about 17 cavans of shelled nuts per hectare. Being grown at the Maligaya Rice Experiment Station, Muñoz, Nueva Ecija.

P. I. No. 11447: Georgia Red.—Introduced from Oneco, Florida, U. S. A., on March 24, 1933. Grown for the first time at the Alabang Rice Experiment Station. This variety is of the bunchy type. The pods are creamy white. Longitudinal ridges and rugae, not very distinct. Usually there are two red kernels in a pod. The kernels which are a little larger than those of the Valencia are about 1.8 centimeters in length. The crop matures in from 150 to 165 days from date of planting, and yields about 14 cavans of shelled nuts per hectare.

P. I. No. 11449: Virginia Jumbo.—Introduced from Oneco, Florida, U. S. A., on March 24, 1933. Grown for the first time at the former Alabang Rice Experiment Station, Alabang, Rizal. The pods of this variety are formed along the lateral

stems, and are with blunt-edged longitudinal ridges; rugae, not so distinct. There are usually two reddish brown kernels in a pod. Matures in from 165 to 185 days, and yields about 18 cavans of shelled nuts per hectare. Being grown at the Maligaya Rice Experiment Station, Muñoz, Nueva Ecija, and at the Los Baños Economic Garden, Los Baños, Laguna.

P. I. No. 13776: Spanish.—Introduced from Reduit, Mauritius, on April 17, 1937. Pods, small averaging 3.2 centimeters in length; strong grower; stems, upright; foliage, abundant and heavy; pods, clustered about base of plant; usually two seeds in a pod; color of peas, light brown; pods adhere well to plant upon digging; longitudinal ridges, rather prominent and sharp; rugae, quite marked. The shell is fairly thick. The period of maturity is from 105 to 125 days. This variety usually yields 19 cavans of shelled nuts per hectare and a ton of hay per acre. The kernels of this variety are rich in oil content. Being grown at the Maligaya Rice Experiment Station, Muñoz, Nueva Ecija and at the Los Baños Economic Garden, Los Baños, Laguna.

P. I. No. 13243: Bukalasa.—Introduced from Entebbe, Uganda, Africa on April 14, 1936. Bunchy type, attaining a height of 32 centimeters; length of vine, 43 centimeters. Shape of pods, bent and twisted, 2 to 4 kernels to the pod; length, 3.45 centimeters; color of shell, cream buff, 2.28 millimeters thick. Shape of kernels, flat at one end and pointed at the other; length of kernel, 1.25 cm. and 0.85 centimeter in diameter. Yield, 24.51 cavans of shelled nuts per hectare. Being grown at the Los Baños Economic Garden, Los Baños, Laguna.

MISCELLANEOUS FRUIT CROPS

P. I. No. 7062: Alpay, Euphoria didyma Bo. (SAPINDACEÆ).—Introduced from Calcutta, India, on October 24, 1919 and grown at the Lamao Experiment Station, Lamao, Bataan. This fruit is also found wild in Cavite, Bataan and other provinces in Luzon. A medium-sized tree with fruits as juicy and sweet as those of the litchi, except that they are green and less meaty. The fruit contains a large, black seed. Found wild in many parts of the Philippines both in dry and humid places. It begins to bear fruits in about 5 to 6 years. Fruiting season: March to June.

P. I. No. 5049: Atemoya, Anona sp. (ANONACEÆ).—A small deciduous tree like the ates. The fruit is sweet and juicy. It

is better in quality and less seedy than the ates. It is a hybrid between the cherimoya and the ates. Introduced into the Islands from the United States, in 1914. Grown at the Lamao Experiment Station, Lamao, Bataan. Thrives best in humid districts about 100 meters above sea level. It begins to bear fruits at the age of three to four years. Fruiting season: April to November.

P. I. No. 1640: Biriba, Rollinia orthopetala A. DC. (ANONACEÆ).—A small to medium sized, semi-deciduous tree. The fruit is heart-shaped with soft projections, and green to yellow in color. The flesh is white, juicy, sweet and of pleasant flavor. A native of Brasil and Guiana. Introduced into the Islands from Mauritius in 1912. Thrives best where there is an even distribution of rainfall. It begins to bear fruits at the age of 3 years. Fruiting season: May to June and October to November.

P. I. No. 3109: Bulala or Laguan, Nephelium mutabile Bl. (SAPINDACEÆ).—Introduced (from Silang, Cavite) at the Lamao Experiment Station, Lamao, Bataan, in 1913. A medium-sized tree with reddish brown, soft, spiny fruits like the rambutan, but less juicy than the latter. Occurs from Northern Luzon to Mindanao and succeeds best in humid districts. It begins to bear fruits in about 6 to 7 years. Fruiting season: May to July.

P. I. No. 8917: Caimito, Chrysophyllum cainito L. (SAPOTACEÆ).—Introduced into the Philippines from Java and Cuba, in 1911. A medium-sized tree with leaves of light golden lower surfaces. The fruit is spherical to oblong in shape, green to brown in color, smooth, with a juicy, sweet and excellent flesh. It is a native of tropical America. It thrives equally well in dry and humid places. It begins to bear fruits at the age of 5 to 6 years. Grown at the Lamao Experiment Station, Lamao, Bataan. Successfully grown especially in the provinces of Cavite, Laguna, and La Union. Fruiting season: January to June. Fruit analysis: moisture, 88.15 per cent; ash, 0.39 per cent; crude fiber, 0.86 per cent; protein, 2.34 per cent; fat, 1.38 per cent; and sugar, 4.4 per cent.

P. I. No. 4097: Cherimoya, Anona cherimolia Mil. (ANONACEÆ).—Introduced into the Philippines from Brisbane, Australia, in 1912. Grown for the first time at the Lamao Experiment Station, Lamao, Bataan. A small tree, 5 to 10 meters high, adapted to high elevations, 750 meters and above. The fruit

is similar to or larger in size than that of the custardapple but it is juicy and deliciously flavored. Successfully grown especially in Bontoc, Mountain Province. Fruiting season: April to December. Fruit analysis: moisture, 66.19 per cent; ash, 0.67 per cent; crude fiber, 4.29 per cent; protein, 1.84 per cent; fat, 0.14 per cent; and sugar, 18.14 per cent.

P. I. No. 3753: Kubili, Cubilia blancoi Bl. (SAPINDACEÆ).—Introduced at the Lamao Experiment Station, Lamao, Bataan, from the Bureau of Forestry, Manila, in 1913. A tree of medium size producing oblong, green and soft spiny fruits; and containing large nuts inside; of excellent flavor when boiled or roasted. Succeeds best where the rainfall is of even distribution. Fruiting season: March to May. Fruit analysis: moisture, 48.24 per cent; ash, 1.47 per cent; crude fiber, 1.21 per cent; protein, 5.2 per cent; fat, 1.92 per cent; starch, 23.13 per cent; and carbohydrates, 18.83 per cent.

P. I. No. 712: Date, Phoenix dactylifera L. (PALMÆ).—Introduced into the Philippines from Syria, in 1911, and grown at the Lamao Experiment Station, Lamao, Bataan. A palm with pinnate leaves and producing the commercial date. It makes a good ornamental. Thrives best where there is very little rainfall and long dry season. The date palm fruited for the first time in Manila in 1930. Analysis of dried date: moisture, 13.80 per cent; ash, 1.2 per cent; protein, 1.9 per cent; fat, 2.5 per cent; and carbohydrates, 70.6 per cent.

P. I. No. 223: Durian, Durio zibethinus L. (BOMBACACEÆ).—Introduced from Singapore, in 1911. A tree 20 meters high, with pointed leaves, silvery beneath. This fruit is quite common in Mindanao and the Sulu Archipelago. Adapted to moist regions at low and medium altitudes. The fruit is large, sometimes exceeding 3 kilos in weight, the whitish, buttery, sweet, aromatic flesh being confined in a hard, bony, and spiny "shell." Fruiting season: January to November. Fruit analysis: moisture, 55.5 per cent; ash, 1.24 per cent; protein, 2.31 per cent; starch, 11.1 per cent; and sugar, 13.55 per cent.

P. I. No. 1675: Galo, Anacolosa luzoniensis M. (OLACACEÆ).—Introduced (from Indang, Cavite) at the Lamao Experiment Station, Lamao, Bataan, in 1912. A tree of medium size about 15 meters high, with alternate simple, pointed leaves; of rather rare occurrence, found from Northern Luzon to Visayas, at low medium elevations. The fruit produced in the axils of the leaves, is a nut of good quality and flavor, about

the size of a filbert. Fruiting season: March to June. Fruit analysis: moisture, 38.5 per cent; ash, 3 per cent; protein, 11.01 per cent; fat, 8.03 per cent; and carbohydrates, 39.46 per cent.

P. I. No. 903: Hevi, Spondias cytherea Son. (ANACARDIACEÆ).—Introduced into the Philippines from Florida, U. S. A., in 1911, and grown for the first time at the Lamao Experiment Station, Lamao, Bataan, where it is successfully grown. A large semi-deciduous tree related to the *siniguelas* with sub-acid fruit as large as a big goose egg. The fruit is orange-yellow when ripe, and has a better keeping quality than the *siniguelas.* The seed is covered with stiff spines to which the flesh is attached. Succeeds well at low altitudes and in dry regions. Begins to bear fruits at the age of 3 to 4 years. Fruiting season: May to December. Fruit analysis: moisture, 85.47 per cent; ash, 0.44 per cent; crude fiber, 0.85 per cent; protein, 0.5 per cent; fat, 0.28 per cent; and sugar, 10.54 per cent.

P. I. No. 2188: Kayam, Inocarpus edulis For. (LEGUMINOSÆ).—A medium sized tree producing a large nut surrounded with fibrous husk, which is hard to separate from the main nut. This nut is prepared and eaten like the chestnut, to which it is similar in taste. Found wild in the Philippines. Propagated in the Lamao Experiment Station, Lamao, Bataan, since 1912. Thrives best both in dry and humid districts. Begins to bear fruits at the age of about 8 to 10 years. Fruiting season: September to November. Fruit analysis: moisture, 48.59 per cent; ash, 1.77 per cent; crude fiber, 0.76 per cent; protein, 5.6 per cent; fat, 1.75 per cent; and carbohydrates, 41.53 per cent.

P. I. No. 5442: Lemasa, Artocarpus champeden Spr. (MORACEÆ).—A tree whose leaves and fruits are very similar to those of the *nangca.* The fruit is of a better quality than the *nangca,* being more fleshy and containing less latex. Introduced from Java, in 1914. Thrives both in dry and humid districts. Begins to bear fruits at the age of 4 to 5 years. Successfully grown in Occidental Negros. Fruiting season: February to September.

P. I. No. 2020: Marang, Artocarpus odoratissima Bo. (MORACEÆ).—Introduced (from Zamboanga) at Lamao Experiment Station, Lamao, Bataan, in 1912. A medium- to large-sized tree with large, sweet, aromatic fruits of good quality. Succeeds best in humid regions with evenly distributed rainfall. Bears fruits at the age of 6 years. Fruiting season: All year round.

P. I. No. 45: Mangosteen, Garcinia mangostana L. (GUTTIFERÆ).—Introduced from Singapore, in 1911. A medium-sized tree with pointed thick, dark green leaves. It is also grown in some parts of Mindanao and Sulu, and adapted to a humid climate, with abundant rains well distributed throughout the year. However, it is found to fruit also in regions with well marked rainfall. The pulp inside the fruit which adheres to the seeds is snow white, sweet and exquisitely flavored. Fruiting season: May to July. Fruit analysis: moisture, 80.2 per cent; ash, 0.23 per cent; protein, 0.5 per cent; and sugar, 16.82 per cent.

P. I. No. 847: Perunkila, Carissa carandas L. (APOCYNACEÆ).—Introduced from Hawaii in 1911 and grown at the Lamao Experiment Station, Lamao, Bataan. A thorny and climbing shrub with small, black and sweet fruit of good flavor about the size of a large duhat but containing much latex. Eaten fresh. It makes a good punch and fairly good pickle. Thrives both in dry and humid regions. Bears fruits at the age of 3 to 4 years. Fruiting season: March to June. Fruit analysis: moisture, 83.23 per cent; ash, 0.66 per cent; crude fiber, 0.62 per cent; protein, 0.39 per cent; fat, 2.57 per cent; starch, trace; carbohydrates, 0.94 per cent; and sugar, 11.58 per cent.

P. I. No. 2730: Berba, Rheedia edulis P. & T. (GUTTIFERÆ).—Introduced from Central America, in 1913. A small tree producing small, brownish or reddish yellow, subacid fruits when fully ripe. The pulp which contains from one to two seeds, is white and recalls the taste of the mangosteen. Thrives well in dry places. Grown at the Lamao Experiment Station, Lamao, Bataan. It begins to bear fruits at the age of 3 years. Fruiting season: April to May and September to December. Analysis: moisture, 84.82 per cent; ash, 0.26 per cent; protein, 1.12 per cent; and sugar, 5.19 per cent.

P. I. No. 2321: Pitanga, Eugenia uniflora L. (MYRTACEÆ).—Introduced from Australia, in 1912. A small shrub bearing reddish, juicy and subacid fruits of the size of a cherry, which when fully ripe are quite delicious. They make a good jelly. Thrives both in dry and humid districts. Bears fruits in about three years. Fruiting season: May to August.

P. I. No. 127: Rambutan, Nephelium lappaceum L. (SAPINDACEÆ).—Introduced from Java, in 1911. Propagated for the first time at the Lamao Experiment Station, Lamao, Bataan. A medium-sized tree with leaves dark green on the upper sur-

face and paler on the nether surface. The fruit is red with soft spines containing a white, juicy flesh of excellent flavor which surrounds a large and oblong seed like that of the cacao. Thrives best in humid regions where the rainfall is well distributed. Bears fruits at the age of about 5 to 6 years. Fruiting season: June to October.

P. I. No. 7080: Tiessa, Lucuma nervosa A. DC. (SAPOTACEÆ).—Introduced from Cuba, in 1915, and grown for the first time at the Lamao Experiment Station, Lamao, Bataan. A small tree producing round to pear-shaped fruit from green to yellow in color and containing 1 to 3 large and brown seeds. The pulp is yellowish, dry, and of a fairly good flavor. Thrives best where the dry season is pronounced. Bears fruits at the age of 3 to 4 years. Successfully grown in the Provinces of Bataan, Cavite and Nueva Ecija. Fruiting season: May to June and October to December. Fruit analysis: moisture, 62.19 per cent; protein, 1.14 per cent; ash, 0.11 per cent; crude fiber, 1.29 per cent; ether extract, 1.18 per cent; and reducing sugar, 9.1 per cent.

P. I. No. 2481: Strawberry var. Wilson, Fragaria chiloensis Dch. (ROSACEÆ).—Introduced from California, U. S. A., in 1913. A low, perennial herb indigenous to South America with carmine-red, juicy, subacid fruits of excellent flavor. Eaten as dessert fruit or preserved. Sucessfully grown in Baguio, Mountain Province. Fruiting season: January to June and December. Fruit analysis: moisture, 90.4 per cent; ash, 0.6 per cent; crude fiber, 1.4 per cent; protein, 1 per cent; fat, 0.6 per cent; and carbohydrates, 6 per cent.

P. I. No. 46: Roselle, Hibiscus sabdariffa L. (MALVACEÆ).—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1911. An herbaceous spreading annual 1.5 to 3 meters high, with large yellowish handsome flowers, the fleshy calyces of which are used in making preserves, jelly, syrup, and wine; the leaves may also be utilized in the manufacture of jelly, syrup and wines; and also boiled and eaten like spinach. Grows well everywhere from sea level up to an altitude of 900 meters. Fruiting season: November to December. Analysis: moisture, 82.49 per cent; ash, 1.23 per cent; and sugar, 1.06 per cent.

AVOCADO, *Persea Americana* MIL. (LAURACEÆ)

P. I. No. 4852: Cardinal.—A tree of medium size. Fruit bottle-necked; nutritious, rich in fat, appetizing, with nutty flavor;

weight, 300 to 500 grams; yellowish green in color before ripening but purple when ripe, with small yellow dots; can be eaten out of hand; makes an excellent ingredient for making ice cream. Introduced into the Philippines from Florida, U. S. A., in 1914. Grown successfully for the first time at the Lamao Experiment Station, Lamao, Bataan. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 200 to 1,000 fruits per tree. Successfully grown especially in the Province of Batangas. Fruiting season: May to September. Fruit analysis: moisture, 88.71 per cent; fat, 3.26 per cent; protein, 0.98 per cent; ash, 0.63 per cent; crude fiber, 1.34 per cent; starch, 2.3 per cent; and reducing sugar, 2.78 per cent.

P. I. No. 3679: Pollock.—Introduced into the Philippines from Miami, Florida, U. S. A., in 1913. The fruit is nutritious, rich in fat, appetizing, with nutty flavor; large, pyriform, weighing 900 to 1,300 grams; color, greenish yellow. Thrives best up to 900 meters above sea level. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Begins to bear fruits at the age of 5 to 6 years. Yields 200 to 500 fruits per tree. Fruiting season: May to August. Fruit analysis: moisture, 86.55 per cent; fat, 5.26 per cent; carbohydrates, 7.26 per cent; protein, 0.176 per cent; ash, 0.657 per cent; and crude fiber, 1.525 per cent.

P. I. No. 4868–A: Family.—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1906. A strong growing tree of spreading habit, being an abundant bloomer and moderate cropper. The fruit is nutritious, rich in fat, and is of good flavor and good quality. It is pear shaped; at times oblong. The color is purple, with scarlet streaks. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields from 200 to 400 fruits per tree. Fruiting season: May to August. Fruit analysis: moisture, 85.93 per cent; fat, 6.77 per cent; carbohydrates, 5.64 per cent; protein, 0.95 per cent; and ash, 0.709 per cent.

P. I. No. 4853: Quality.—Introduced from California, U. S. A., in 1907. Fruit obovate to pyriform, weighing 300 to 600 grams; length, 5 to 6 inches; greenish yellow color even when ripe with small maroon dots and a few brown spots. Flesh, whitish yellow; good flavor; good quality; rich in fat. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Thrives best up to 900 meters above sea level. It begins to bear fruits

at the age of 5 to 6 years. Yields 200 to 300 fruits per tree. Fruiting season: May to July.

P. I. No. 4866: Lyon.—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1903. Fruited for the first time at the Lamao Experiment Station, Lamao, Bataan. Fruit, oblong pyriform and indistinctly necked in form; weight, 400 to 900 grams; nutritious; of rich flavor and good quality. Thrives best up to 2,500 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 300 to 600 fruits per tree. Fruiting season: May to August. Fruit analysis: moisture, 85.93 per cent; fat, 6.77 per cent; carbohydrates, 5.641 per cent; protein, 0.95 per cent; and ash, 0.709 per cent.

P. I. No. 4854: Cyrus.—Introduced from Florida, U. S. A., in 1907. Grown successfully for the first time at the Lamao Experiment Station, Lamao, Bataan. Fruit, oblong pyriform, weighing from 350 to 450 grams; greenish yellow or yellowish green even when ripe with yellow dots; rich in flavor; good quality. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 200 to 400 fruits per tree. Fruiting season: July to September. Fruit analysis: moisture, 81.76 per cent; fat, 10.12 per cent, carbohydrates, 6.209 per cent; protein, 0.923 per cent; and ash, 0.988 per cent.

P. I. No. 4844: Wester.—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1913. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Fruit, roundish oblate, obliquely flattened at the apex, weighing 300 to 600 grams; skin, leathery light green color before ripening but turns to deep purple with maroon russet dots when ripe, adhering closely to the flesh; flesh firm, light yellow color; rich flavor; quality good. Thrives best up to 900 meters above sea level. It begins to bear fruit after 5 to 6 years. Yields, 200 to 400 fruits per tree. Fruiting season: August to October. Fruit analysis: moisture, 84.24 per cent; fat, 7.67 per cent; protein, 1.02 per cent; ash, 0.85 per cent; crude fiber, 1.28 per cent; starch, 2.94 per cent; and reducing sugar, 2 per cent.

P. I. No. 6018: Fuerte.—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1917. Fruit, pyriform to oblong, weighing from 300 to 400 grams; flesh, rich creamy yellow in color; greenish near the skin; very rich in

flavor; excellent quality. Thrives best at an elevation of 600 meters and above. It begins to bear fruits at the age of 5 to 6 years. Yields 100 to 200 fruits per tree. Fruiting season: August to September. Fruit analysis: moisture, 60.86 per cent; ash, 1.35 per cent; protein, 1.25 per cent; fat, 29.14 per cent; and carbohydrates, 7.4 per cent.

P. I. No. 3678: Baldwin.—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1913. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Shape of fruit, approaching oblong; 4 by 5½ inches; flavor, excellent. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 100 to 300 fruits per tree. Fruiting season: August to October.

P. I. 1397: Cummins.—Introduced from Honolulu, Hawaii, in 1912. Successfully grown at the Lamao Experiment Station, Lamao, Bataan. Fruit, roundish oblate, weighing from 200 to 400 grams; bright green to yellowish green but turns dark purple when ripe with yellow to russet dots; good flavor, excellent quality. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields from 100 to 200 fruits per tree. Fruiting season: September to October.

P. I. No. 4850: Commodore.—Introduced from Florida, U. S. A., in 1906. Grown successfully for the first time at the Lamao Experiment Station, Lamao, Bataan. Fruit, from obovate to pyriform, weighing from 160 to 400 grams; surface glossy, yellowish green before ripening and deep purple when ripe with small yellow dots; flesh, light yellow changing to very light yellowish green towards the skin; rich flavor; quality fair. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields from 100 to 200 fruits per tree. Fruiting season: July to September. Fruit analysis: moisture, 84.35 per cent; fat, 8.13 per cent; protein, 0.64 per cent; ash, 0.81 per cent; crude fiber, 1.21 per cent; starch, 3.07 per cent; and reducing sugar, 1.79 per cent.

P. I. No. 4849: Vega.—Introduced from Cuba, in 1906. Grown successfully for the first time at the Lamao Experiment Station, Lamao, Bataan. Fruit from obovate to broad pyriform, not necked; weight, 300 to 500 grams; surface undulating to rough but glossy, yellowish green before ripening and when ripe, exhibiting small yellowish dots; flesh, creamy color, tinged

with green towards the skin; rich flavor; good quality. Thrives best up to an elevation of about 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 100 to 200 fruits per tree. Fruiting season: August to September.

P. I. No. 4855: Miami.—Introduced from Florida, U. S. A., in August, 1907. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Matured fruits are dark green in color, turning yellowish green on ripening, weighing 200 to 300 grams; round to slightly oval in shape; good flavor; good quality. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 100 to 200 fruits per tree. Fruiting season: July to September. Fruit analysis: moisture, 85.03 per cent; carbohydrates, 3.28 per cent; protein, 0.93 per cent; ash, 0.44 per cent; crude fiber, 1.08 per cent; ether extract, 7.5 per cent; and reducing sugar, 1.74 per cent.

P. I. No. 4872: Douglas.—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1906. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Fruit obovate to pyriform and indistinctly necked; weight, 400 to 500 grams; surface smooth and glossy, yellowish green before ripening and deep purple when ripe with yellow dots; flesh, cream yellow in color; of rich flavor and good quality. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields from 100 to 150 fruits per tree. Fruiting season: August to October. Fruit analysis: moisture, 86.88 per cent; fat, 6.31 per cent; carbohydrates, 5.19 per cent; protein, 0.72 per cent; and ash, 0.9 per cent.

P. I. No. 6026: Puebla.—Introduced from California, U. S. A., in 1910. Form of fruit, obovoid, slightly oblique; weight, 300 to 400 grams; surface, smooth, glossy, deep maroon-purple with numerous reddish dots; flesh, rich cream yellow; buttery in texture, and of rich nutty flavor; quality, very good. Thrives best at an elevation of 600 meters and above. It begins to bear fruits at the age of 5 to 6 years. Yields 150 to 250 fruits per tree. Fruiting season: May to September. Fruit analysis: moisture, 63.32 per cent; ash, 1.56 per cent; protein, 1.8 per cent; fat, 26.68 per cent; and carbohydrates, 6.64 per cent.

P. I. No. 6019: Sharpless.—Introduced from U. S. Department of Agriculture, Washington, D. C., in 1917. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Fruit slen-

der pyriform; weight, 500 to 700 grams: somewhat rough; purple; of good flavor and good quality. Thrives best up to 2,500 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 100 to 200 fruits per tree. Fruiting season: June to September. Fruit analysis: moisture, 71.21 per cent; ash, 1.12 per cent; protein, 1.76 per cent; fat, 20.54 per cent; and carbohydrates, 5.43 per cent.

P. I. No. 9118: Trapp.—Introduced from U. S. Department of Agriculture, Washington, D. C., in 1926. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Form of fruit, roundish oblate, obliquely flattened at the apex; weight, 500 to 700 grams; surface, smooth to undulating or slightly pitted; pale yellow-green, with numerous small to medium-sized, irregular, pale greenish yellow dots; flesh firm, very smooth, rich cream yellow changing to pale green near the skin; flavor, moderately rich, pleasant; quality good. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 150 to 300 fruits per tree. Fruiting season: June to October. Fruit analysis: moisture, 78.66 per cent; ash, 0.85 per cent; protein, 1.61 per cent; fat, 9.8 per cent; and carbohydrates, 9.08 per cent.

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ILLUSTRATIONS

PLATE 1

A field of P.O.J. 2878 (P. I. No. 4910).

PLATE 2

Badila cane (P. I. No. 8743).

PLATE 3

A field of Napier grass, *Pennisetum purpureum* Schum. (P. I. No. 5488). Lamao Experiment Station, Limay, Bataan.

PLATE 4

Guinea grass, *Panicum maximum* Jacq. (P. I. No. 1819) at the Singalong Experiment Station, Manila.

PLATE 5

A field of Guatemala grass, *Tripsacum laxum* Nees. (P. I. No. 6933) at the Lipa Demonstration Station, Lipa, Batangas.

PLATE 6

Peanut varieties. From left to right: San Jose No. 1 (P. I. No. 7980); Bukalasa (P. I. No. 13243); and Tennessee Red (P. I. No. 13769).

PLATE 7

Two plots of peanuts: Virginia Jumbo (P. I. No. 11449), left, and Spanish (P. I. No. 13766), right.

PLATE 8

A bearing caimito, *Chrysophyllum cainito* L. (P. I. No. 8917) at the Los Baños Economic Garden, Los Baños, Laguna.

PLATE 9

A bearing cherimoya tree, *Anona cherimolia* Mil. (P. I. No. 4097) at the Central Experiment Station, Manila.

PLATE 10

Roselle plants, *Hibiscus sabdariffa* L. (P. I. No. 46) in bloom.

PLATE 11

A budded Cardinal avocado (P. I. No. 4852) at the Lamao Horticultural (formerly Lamao Experiment) Station, Limay, Bataan.

PLATE 1.

PLATE 2.

PLATE 3.

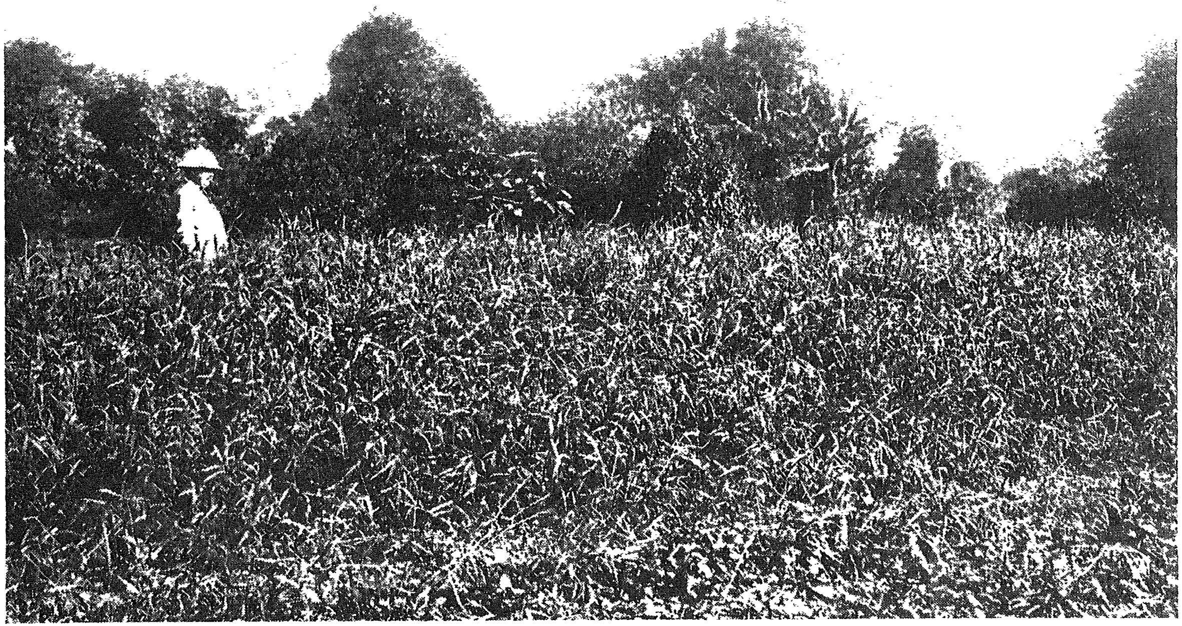

PLATE 4.

PLATE 5.

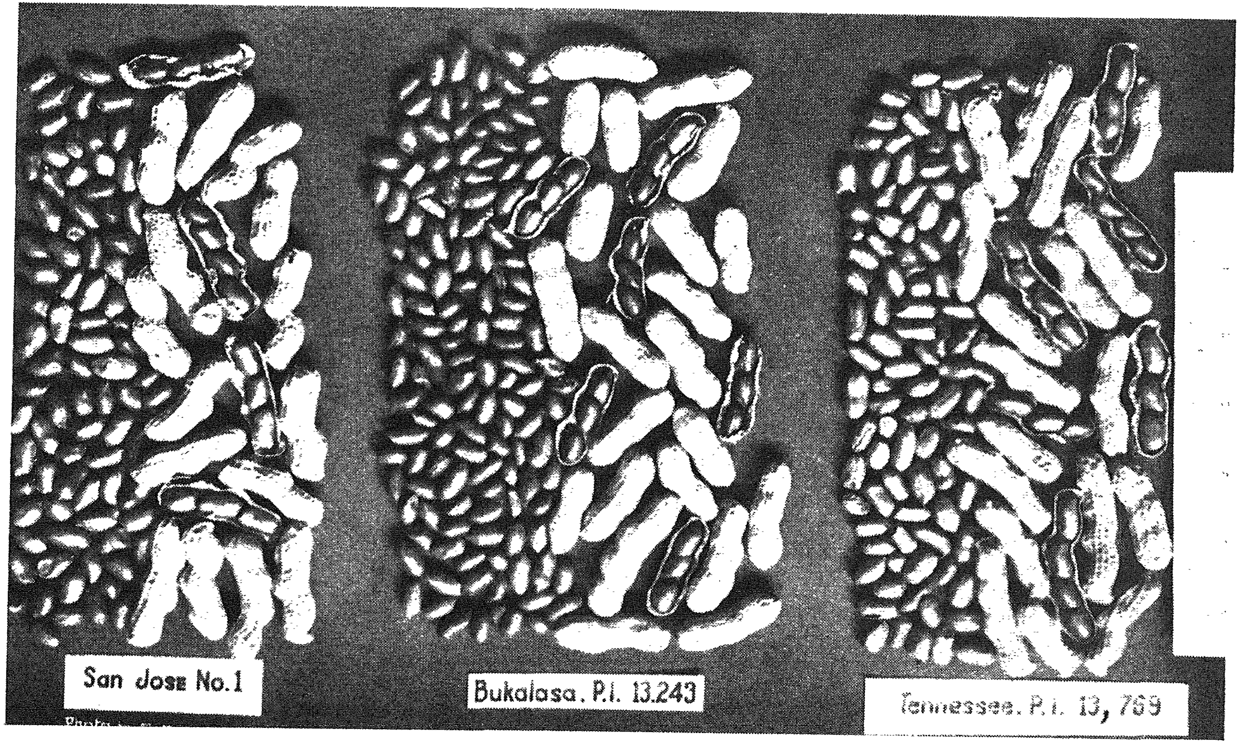

PLATE 6.

PLATE 7.

PLATE 9.

PLATE 10.

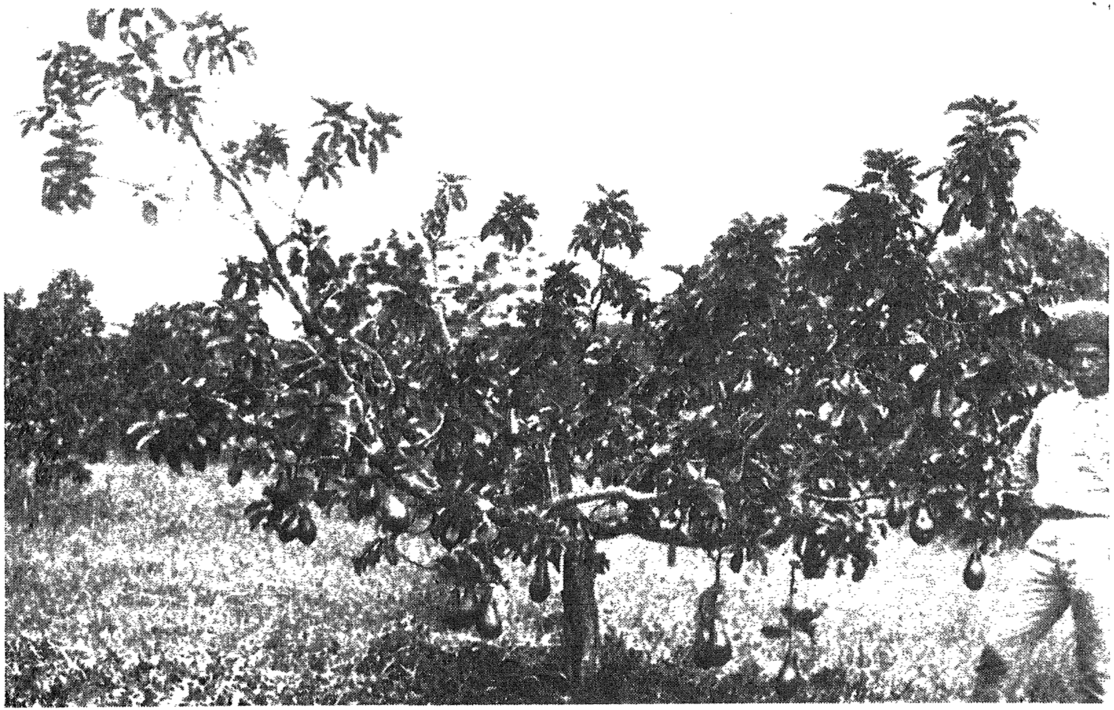

PLATE 11.

RICE CADANG-CADANG IN ALBAY PROVINCE: II. FERTILIZER TREATMENTS

By JULIAN A. AGATI and FERNANDO DE PERALTA
Of the Bureau of Plant Industry

Just after the pot fertilizer experiments were completed and plans were being made to extend the results in the field, the Provincial Board of Albay appropriated the sum of ₱500 to finance field studies on the malady. Since the Bureau was called upon to undertake the project, a plan of experiments based on the results obtained from the previous pot culture studies was immediately prepared.

In the previous pot culture experiments, (1) and (2) it was found that rice *cadang-cadang* was largely the result of plant food deficiency in the soil, particularly nitrogen. Following this significant lead, treatments using commercial fertilizers were conducted in previously *cadang-cadang* infested soils in Albay Province.

The field experiments were started in April, 1938 and ended in September, 1938. The places selected for the projects were Kinale, Polangui; Mayao, Oas; and Ologon, Libon,[1] all of Albay Province. These towns were believed to be ideal for the experiments because they are known to be previously affected by rice *cadang-cadang*. Moreover, the soil samples used for analyses and for pot culture studies were obtained from the abovementioned places.

The aims in undertaking the field experiments were: (1) to conduct a field test of the fertilizers found in the laboratory to reduce the effects of *cadang-cadang* and (2) to determine, under field conditions, the most desirable combination of the suitable fertilizers and the rate at which they may be applied per hectare with a reasonable profit.

[1] Two days after the application of fertilizers there was a heavy downpour, inundating the entire field. Before and during the blooming period heavy rains and strong winds again occurred. These conditions affected adversely the experiments so that their inclusion here is not advisable.

MATERIALS AND METHODS

Preparation of the fields.—The land was first irrigated to soften it before plowing. The clods were broken and the weeds removed by thorough harrowing. The entire field was flooded, keeping the weeds submerged until they rotted, after which time the water was drained off so that the land could be harrowed and leveled again preparatory to planting.

The dikes, about 25 cm. high and 25 cm. wide, were made next. They were constructed in such a way that one plot could be irrigated independently of the others, thus avoiding mixing the fertilizers that were applied later.

Each experimental field was divided by dikes into equal plots of almost 120 square meters each. These individual plots were further subdivided into smaller unit plots by smaller dikes, each having an area of approximately 40 square meters. In Kinale, Polangui, there were 60 unit plots, 45 of which were treated and 15 were checks. The same number of unit plots was employed in Mayao, Oas; 45 were fertilized and the rest used as controls.

Transplanting.—The seedlings used were of the Baranay variety, which is planted there extensively. The seedlings which were at least 45 days old were furnished by our coöperators. Three seedlings were planted to a hill in order to give allowance for deaths. The distance between hills was 25 cm. each way. The Kinale experiment was started on May 5, 1938, and that at Oas, on June 7, 1938.

Application of fertilizers.—The fertilizers were applied about one month after transplanting. Before the applications were made, the individual plots were drained of their water, keeping them just sufficiently moist so as to insure a uniform effect of the fertilizers. The fertilizers, especially the combined ones, were ground and mixed thoroughly before they were broadcasted evenly on the plots. After ten days, or as soon as the fertilizers were incorporated in the soil, the plots were again irrigated taking care that no overflowing or mixing of the fertilizers from different paddies occurred. The irrigation was maintained up to blooming period, but as soon as the grains began to form the water was gradually drained from the plots until there was practically no water at harvest time.

The commercial fertilizers used were sulphate of ammonia, double superphosphate of lime and sulphate of potash. The

combinations or treatments used were N, NP, NK, and NPK. These treatments or combinations were applied at the following rates: The minimum rate of fertilizers applied was 150 kilos per hectare; the medium rate, 200 kilos per hectare; and the maximum rate, 250 kilos per hectare.

For the sake of brevity in the discussion, the treated plots were designated as A_1 to A_3; B_1 to B_3; C_1 to C_3 and the controls were represented by D. The symbols, A_1, A_2 and A_3 stand for the nitrogen (N) treatment. A_1 represents the minimum rate of application, A_2, the medium rate of application, and A_3 the maximum rate of application. The letters B were used to designate the sulphate of ammonia and double superphosphate of lime (NP) applications in three different amounts as already mentioned above. The letters C represent the complete fertilizer treatments (NPK) in different amounts and the letter D stands for the control.

In order to determine the effect or value of adding fertilizers in controlling *cadang-cadang*, the following observations were made: (1) the general stand of the plants; (2) the occurrence of *cadang-cadang;* (3) the average height of plants; (4) the average number of tillers; (5) the average weight of clean palay. and (6) the computed yield per hectare in kilos and cavans.

The height of the plants and the number of tillers were observed and recorded monthly from the time the plants were about one month old to the time of maturity and harvest. It was necessary to carry monthly observations in order to determine at what stage the rice plants succumbed to *cadang-cadang*. There were measured 20 plants from each treatment, which was replicated five times. In measuring the plants, bamboo stakes were driven at the base of each plant to be measured in order to avoid confusion in the succeeding measurements and thus minimize errors in our records. Each plant was measured from its base to the highest leaf tip. For obvious reasons the yields were not computed on the hectare basis but were given as the actual average production per plant per treatment. The yields from the individual plots, however, were used in computing the yields on a hectare basis, and thus evaluate each treatment in its effect in minimizing the damage by *cadang-cadang*.

RESULTS

The results of the experiments are shown in the following tables:

TABLE 1.—*Comparative effects of fertilizers on the stand, growth and yield per plant in Kinale, Polangui where cadang-cadang was previously rampant*

Plot number	Treatment and rate of application per hectare (kilos)		Average height of plants (cm.)	Average number of tillers	Average yield per plant based on 100 plants (gms.)	Probable error of difference	Treated and control compared	Observations on the stand and growth of plants
A_1	Ammonium sulphate	150	150	12.0	37.32 ±2.3030	14.54 ±2.4212	Significant	Fairly good stand, no *cadang-cadang*.
A_2	Ammonium sulphate	200	152.7	13.0	36.32 ±1.7046	13.54 ±1.8614	do	Do.
A_3	Ammonium sulphate	250	149.0	13.5	34.88 ±3.2219	12.10 ±3.3075	do	Good stand, no *cadang-cadang*.
B_1	Ammonium sulphate	150	141.6	11.8	31.92 ±2.0756	9.14 ±2.2062	do	Fairly good stand, no *cadang-cadang*.
	Double superphosphate	150						
B_2	Ammonium sulphate	200	148.8	12.4	32.26 ±2.2074	9.48 ±2.3306	do	Do.
	Double superphosphate	200						
B_3	Ammonium sulphate	250	151.9	14.0	34. 4 ±2.7991	11.62 ±2.8973	do	Good stand, no *cadang-cadang*.
	Double superphosphate	250						
C_1	Ammonium sulphate	150	147.9	13.6	35.78 ±2.5354	13.0 ±2.6434	do	Do.
	Double superphosphate	150						
	Potassium sulphate	150						
C_2	Ammonium sulphate	200	151.3	12.25	31.92 ±1.6004	9.14 ±1.7665	do	Fairly good stand, no *cadang-cadang*.
	Double superphosphate	200						
	Potassium sulphate	200						
C_3	Ammonium sulphate	250	178.3	14.5	36. 2 ±2.8880	13.42 ±2.9832	do	Do.
	Double superphosphate	250						
	Potassium sulphate	250						
D (Control)	No fertilizer		117.5	7.5	22.78 ±0.7480			The plants were yellow and somewhat stunted, *cadang-cadang* present.

TABLE 2.—*Comparative effects of fertilizers on the yields of the experimental plots in Kinale, Polangui where cadang-cadang was previously rampant*

Plot number	Treatment and rate of application per hectare (kilos)		Actual average yield per plot (kilos)	Computed yield per hectare		Probable error of difference	Treated and control compared	Observations on the stand and growth of plants
				Kilos	Cavans			
A_1	Ammonium sulphate	150	10.1	2 525.0	57.91 ±2.4619	13.19 ±2.540	Significant	*Cadang-cadang* symptom absent.
A_2	Ammonium sulphate	200	10.2	2,550.0	58.48 ±3.8783	13.76 ±3.9284	do	Do.
A_3	Ammonium sulphate	250	11.2	2,750.0	64 21 ±3.1210	19.49 ±3.2143	do	Do.
B_1	Ammonium sulphate Double superphosphate	150 150	11.0	2,750.0	63.07 ±3.8875	18.35 ±3 9374	do	Do.
B_2	Ammonium sulphate Double superphosphate	200 200	11.3	2,825.0	64.78 ±1.2003	20.06 ±1.3534	do	Do.
B_3	Ammonium sulphate Double superphosphate	250 250	12.1	3,025.0	69.33 ±5.6504	24.66 ±5.6849	do	Do.
C_1	Ammonium sulphate Double superphosphate Potassium sulphate	150 150 150	10.4	2 550 0	59.63 ±1.0175	14.91 ±1 1943	do	Do.
C_2	Ammonium sulphate Double superphosphate Potassium sulphate	200 200 200	11.9	2,975 0	68.23 ±3.6205	23.41 ±3.6741	do	Do.
C_3	Ammonium sulphate Double superphosphate Potassium sulphate	250 250 250	14.3	3,575.0	81.99 ±1.4262	37.27 ±1.5572	do	Do.
D (Control)	No fertilizer		7.8	1,950 0	44.72 ±0.6254			*Cadang-cadang* symptom present.

TABLE 3.—*Comparative effects of fertilizers on the stand, growth and yields per plant in Mayao, Oas, where cadang-cadang was previously rampant*

Plot number	Treatment and rate of application per hectare (kilos)	Average height of plants (cm.)	Average number of tillers	Average yield per plant based on 100 plants (gms.)	Probable error of difference	Treated and control compared	Observations on the stand and growth of plants
A_1	Ammonium sulphate 150	140.0	12 0	39.4 ±2.3239	17.32±2.6778	Significant	Good stand, no *cadang-cadang*.
A_2	Ammonium sulphate 200	127.2	12.1	39.8 ±1.4593	17.72±1.9748	do	Do.
A_3	Ammonium sulphate 250	127.4	12.0	36.28±3.1946	14.2 ±3.4606	do	Fairly good stand, no *cadang-cadang*.
B_1	Ammonium sulphate 150 Double superphosphate 150	109.0	10.0	34.12±2.0326	12.04±2.4293	do	Do.
B_2	Ammonium sulphate 200 Double superphosphate 200	109.4	12.0	34.36±2.1154	12.28±2.4990	do	Good stand, no *cadang-cadang*.
B_3	Ammonium sulphate 250 Double superphosphate 250	116.0	9.0	36.72±2.8022	14.64±3.1020	do	Do.
C_1	Ammonium sulphate 150 Double superphosphate 150 Potassium sulphate 150	115.5	9.7	39.02±2.3331	16.94±2.6858	do	Do.
C_2	Ammonium sulphate 200 Double superphosphate 200 Potassium sulphate 200	112.2	12.0	34.38±1.5850	12.30±2.0694	do	Fairly good stand, no *cadang-cadang*.
C_3	Ammonium sulphate 250 Double superphosphate 250 Potassium sulphate 250	109.7	11.8	39.64±2.7769	17.56±3.2607	do	Do.
D (Control)	No fertilizers	87.5	7.5	22.08±1.3306			The plants were yellow and stunted; *cadang-cadang* present.

TABLE 4.—*Comparative effects of fertilizers on the yields of the experimental plots in Mayao, Oas where cadang-cadang was previously rampant*

Plot number	Treatment and rate of application per hectare (kilos)	Actual average yield per plot (kilos)	Computed yield per hectare		Probable error of difference	Treated and control compared	Observations on the stand and growth of plants
			Kilos	Cavans			
A_1	Ammonium sulphate 150	9.66	2,415.0	55.37 ±1.0869	20.39 ±1.6721	Significant	*Cadang-cadang* symptom absent.
A_2	Ammonium sulphate 200	10.65	2,662.50	61.05 ±1.0945	26.07 ±1.6899	do	Do.
A_3	Ammonium sulphate 250	8.4	2,100.00	48.14 ±2.6888	13.16 ±2.9812	do	Do.
B_1	Ammonium sulphate 150 Double superphosphate 150	8.65	2,162.50	58 8 ±1.1649	23.82 ±1.7363	do	Do.
B_2	Ammonium sulphate 200 Double superphosphate 200	8.87	2,217.50	50.78 ±1.8855	15.80 ±2.2832	do	Do.
B_3	Ammonium sulphate 250 Double superphosphate 250	9.16	2,290.00	51.35 ±1.7046	16.37 ±2.1362	do	Do.
C_1	Ammonium sulphate 150 Double superphosphate 150 Potassium sulphate 150	7.6	1,900.0	43.56 ±1.5155	8.58 ±1.9855	do	Do.
C_2	Ammonium sulphate 200 Double superphosphate 200 Potassium sulphate 200	8.6	2,150.0	49.29 ±2.4465	14.31 ±2.7646	do	Do.
C_3	Ammonium sulphate 250 Double superphosphate 250 Potassium sulphate 250	7.6	1,913.0	43.56 ±1.5115	8.58 ±1.9655	do	Do.
D (Control)	No fertilizers	6.1	1,525.0	34.98 ±1.0876			*Cadang-cadang* symptom present.

DISCUSSION OF RESULTS

(*a*) *The Kinale experiments.*—At the start, both fertilized and control plants were practically of the same stand. However, two weeks after the application of fertilizers, the treated plants showed a conspicuous headway, while the controls were generally of uneven stand and of poor growth. A month or so later, the plants treated with nitrogen of various amounts showed dark, broad, green leaves in contrast with those of the controls, which were generally stunted, having thin stalks, few tillers and narrow, pale and dry leaves.

Referring to table 1, and considering the nitrogen treatment first, it is apparent that the heights of the plants, irrespective of the amount applied, did not vary very much. All those under the different treatments came well within the 150-centimeter mark. The same may also be said of the number of tillers and average yield per plant based on 100 individuals. The variation was not much.

Taking up the double superphosphate-ammonium sulphate treatment, the heights of the plants varied proportionately with the amount of fertilizers used. The plants, however, were generally smaller than those treated with nitrogen alone. The number of tillers and average yield per plant were irregular but both varied according to the proportions of the fertilizers used.

The plants treated with complete fertilizers attained certain heights that varied according to the amounts of fertilizers applied. Although the tillering habits were as good as those in the other treatments, the plants did not follow the variations in the amounts of fertilizers applied. It is interesting to note, however, that the yields were no better than those of the other treatments. On the contrary, the nitrogen treatment showed even a more decided advantage in yield.

The controls reached just a little over a meter high, produced only one-half as many tillers as those of the treated, and gave considerably lower yields.

In table 2, the computed yields per hectare in cavans of those treated with different fertilizers were generally higher than those of the controls.

Considering the results obtained from the three different treatments and picking at random only the good yields so that they could be arranged in consecutive order, it is apparent that the maximum application of nitrogen gave 64 cavans to the

hectare, the maximum application with double superphosphate-ammonium sulphate, 69 cavans, while that of the complete fertilizer mixture gave 81 cavans. While the value of this result is self-evident, it does not seem safe to say that this will always hold true, and that therefore the other treatments are to be left out of consideration. For example, the results from using a maximum amount of nitrogen which are more or less equal to those obtained from using a medium amount of double superphosphate-ammonium sulphate mixture, are even better than the results derived with the use of the minimum amount of complete fertilizer mixture. Likewise, the use of the maximum amount of phosphate-ammonium sulphate was even more successful than that of medium complete mixture. Although the maximum phosphate-ammonium sulphate mixture and both the medium and maximum complete fertilizer mixtures, respectively, were apparently good, nitrogen treatment may still be preferred if production cost is considered.

(*b*) *Mayao experiments.*—Like the results obtained in Kinale, the most noticeable characteristic of the Mayao experiments, is the great contrast between the treated plants and the controls. While the fertilized plants produced conspicuously broad, green leaves after a month or so of growth, the controls did not only exhibit uneven stand and stunted growth but they also presented a somewhat burned appearance from a distance. This showed unmistakably the effects of *cadang-cadang*. At harvest time, the control plants did not only produce slender stalks and few tillers but also gave considerably much smaller yields than the treated.

Referring to table 3 and taking into account the heights of the plants treated with different amounts of ammonium sulphate, it is surprising to note that the minimum application of nitrogen produced the tallest plants. Those with medium and maximum applications, besides being smaller than those treated with minimum amount, were uniformly the same, and so with the number of tillers in both cases. These differences in the vegetative growth did not materially vary the yields, which were practically the same in all cases.

In the double superphosphate-ammonium sulphate mixture, the tallest plants were found among those treated with maximum applications of the mixture, although they produced comparatively few tillers. These slight differences did not vary the yields, which remained uniformly the same.

The plants treated with a complete mixture were practically uniform in height, irrespective of the amounts of the mixture used. The tillers, however, were more predominant with the use of more of the fertilizers. These slight differences in the stand of the plants were not sufficient to vary the yields among the different treatments.

The controls were comparatively small and were even below one meter high. The tillers were few and the plants as a whole yielded very little, showing the effects of *cadang-cadang*.

Considering the yields in cavans as given in table 4, the effects of the ammonium sulphate application were conspicuous. It is also apparent that the harvests from the phosphate-nitrogen treatment, although generally less than those of the nitrogen applications, were even better than those obtained from the use of a complete fertilizer mixture regardless of the amounts applied. Apparently this implies two things: one is that nitrogen may still prove to be the most economical to use under Mayao conditions, and another is that nitrogen helps a great deal in minimizing the effects of *cadang-cadang;* hence it augments the yield. Mayao has been known to be more severely infested previously with *cadang-cadang* than the lot in Kinale. It seems thus evident that, although the results of the experiments as indicated by the use of fertilizers that the *cadang-cadang* malady is linked with a deficiency in or insolubility of soil nutrients, nitrogen and phosphoric acid seem to be most deficient in amount as far as Mayao is concerned. This does not seem so in the case of Kinale, yet the limiting effect of nitrogen can not be ignored in the latter place.

THE ECONOMICS OF THE EXPERIMENTS

In estimating the increase in yields due to the treatments, the cost of fertilizers and application was considered. Thus, basing from the prices of the fertilizers obtained from Menzi and Co.[1] and the current selling price of clean palay at ₱2.50 per

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[1] The prices of the fertilizers used were as follows:

1 ton, sulphate of ammonia	₱ 92.00, or ₱ 4.85 per sack of 50 kg.
1 ton, double superphosphate of lime	₱125.00, or ₱13.00 per sack of 100 kg.
1 ton, sulphate of potash	₱120.00, or ₱12.50 per sack of 100 kg.

cavan, and the expenses involved, the profit gained or the losses sustained in the experiment may be tabulated as follows:

TABLE 5.—*Summary results of the experiments in Kinale, Polangui.*

Treatments: Fertilizers used	Treatments: Rate per hectare	Increase in yield over control per hectare	Value of increased yield per hectare	Cost of fertilizers and application	Gain (+) or loss (—) per hectare
	Kilogram	*Cavans*	*Pesos*	*Pesos*	*Pesos*
Ammonium sulphate	150	13.19	32.98	14.80	+18.18
Do	200	13.76	34.40	19.40	+15.00
Do	250	19.49	48.72	24.00	+24.72
Do	150	18.35	45.87	34.05	+11.82
Double superphosphate	150				
Ammonium sulphate	200	20.06	50.15	44.90	+ 5.25
Double superphosphate	200				
Ammonium sulphate	250	24.66	61.65	55.75	+ 5.90
Double superphosphate	250				
Ammonium sulphate	150	14.91	37.27	46.55	— 9.28
Double superphosphate	150				
Potassium sulphate	150				
Ammonium sulphate	200	23.41	58.52	63.40	— 4.88
Double superphosphate	200				
Potassium sulphate	200				
Ammonium sulphate	250	37.27	93.17	80.25	+12.92
Double superphosphate	250				
Potassium sulphate	250				

TABLE 6.—*Summary results of the experiments in Mayao, Oas.*

Treatments: Fertilizers used	Treatments: Rate per hectare	Increase in yield over control per hectare	Value of increased yield per hectare	Cost of fertilizers and application	Gain (+) or loss (—) per hectare
	Kilogram	*Cavans*	*Pesos*	*Pesos*	*Pesos*
Ammonium sulphate	150	20.39	50.97	14.80	+36.17
Do	200	26.07	65.17	19.40	+45.77
Do	250	13.16	32.90	24.00	+ 8.90
Do	150	23.82	59.55	34.05	+25.50
Double superphosphate	150				
Ammonium sulphate	200	15.80	39.50	44.90	— 5.40
Double superphosphate	200				
Ammonium sulphate	250	16.37	40.92	55.75	—14.83
Double superphosphate	250				
Ammonium sulphate	150	8.58	21.45	46.55	—25.10
Double superphosphate	150				
Potassium sulphate	150				
Ammonium sulphate	200	14.31	35.77	63.40	—27.63
Double superphosphate	200				
Potassium sulphate	200				
Ammonium sulphate	250	8.58	21.45	80.25	—58.80
Double superphosphate	250				
Potassium sulphate	250				

Considering the nitrogen treatments in table 5, the 250-kg. application appears to be most profitable, the 200-kg. rate comparatively poor, and the 150-kg. treatment fairly good.

Of the NP combinations, the use of 150 kg. per hectare is fairly profitable, whereas both the 200-kg. and 250-kg. treatments yielded almost equal profits.

The complete mixture (NPK) is profitable when applied at the rate of 250 kg. per hectare.

It is thus apparent that, with the Kinale experiment, only two cases out of the 9 different treatments did not show profits, yet the best results, as far as monetary returns are concerned, were obtained with the maximum application of N, the minimum application of NP, and the maximum application of NPK. This indicates that nitrogen alone, or in combination with P_2O_5, when applied to *cadang-cadang* soil, yielded reasonable profits.

As regards the Mayao experiments, the two nitrogen treatments yielded substantial gains. With the nitrogen-phosphoric acid treatment, only the minimum rate showed a profitable return while neither of the other two rates showed any gain. The complete fertilizer treatments were all considerably below cost.

From the foregoing discussions, it is evident that although all the treated fields outyielded their corresponding controls as previously seen in the discussion of yields, all the treatments, however, did not prove to be profitable when the cost of fertilizers and the cost of application were taken into account. This was more striking in the case of the Mayao field. The results of these experiments present some facts worthy of consideration. It would seem that although the fertilizers were required by the plants, there is a certain limit beyond which their application will no longer be profitable. It would seem also that the kind of combinations and amounts of fertilizers used determine largely the results of the experiment. These two factors apparently were at work in our experiments.

SUMMARY

1. The present paper gives the results of experiments in the field using different amounts and mixtures of commercial fertilizers in an effort to minimize the infestation of *cadang-cadang*.

2. The experiments were conducted in two different places where *cadang-cadang* was known to have gotten a foothold during the last two planting seasons.

3. As shown by the controls, *cadang-cadang* appears a month or so after transplanting; the plants are stunted and they present an uneven stand, and the leaves are pale green to yellow.

4. The results of the experiments point out the possibility of making *cadang-cadang* soils more productive by the use of such commercial fertilizers as sulphate of ammonia, double superphosphate of lime and sulphate of potash.

5. When the costs of fertilizers and application are considered, the use of sulphate of ammonia alone, applied at the rate of 150–250 kg. per hectare, proved as profitable as with the use of a mixture of double superphosphate and sulphate of ammonia or a mixture of double superphosphate, sulphate of ammonia and sulphate of potash applied at the same rate per hectare.

ACKNOWLEDGMENTS

The writers wish to express their gratitude to Mr. H. S. Silayan, Director of Plant Industry for his encouragement during the progress of the work; to Dr. G. Merino, Chief, Plant Pest and Disease Control Division; Dr. F. M. Clara, Chief, Plant Pathology Section; and Mr. F. G. Galang, Chief, Horticulture Section for affording them the opportunity to work on the project; to the Governor and Provincial Board of Albay for appropriating the money needed for the experiments; to Mr. Julian C. Ilagan, Acting Provincial Agricultural Supervisor, and his staff for their valuable coöperation and help during the progress of the work; and lastly to Messrs. Anastacio Ante and Ubaldo Robueno for consenting to the use of their land for carrying out the experiments.

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STUDY ON THE VITALITY OF OLD AND NEW SEEDS OF MUNGO (*PHASEOLUS AUREUS* ROXB).[1]

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ONE PLATE

That the seeds of many economic plants can maintain their viability for a number of years under proper storage conditions have been shown by a number of investigators, (2), (3), (4), (5) and (6). This leads to some speculation at least as to the value of old but viable seeds for planting purposes. As a matter of fact, the writer (3), in the discussion of the results of his studies on the longevity of some farm crop seeds, pointed out the possibility for "plant breeders who are testing a large number of varieties and strains under limited means. . . . to store part of their materials to be tested gradually in later years." This possibility was pointed out on the assumption that old and new seeds of the same variety or strain with good viability have practically the same yielding power.

To obtain some information on the behavior of old seeds as planting materials, the writer undertook a study on the vitality of old and new seeds of mungo, *Phaseolus aureus* Roxb. It may also be pointed out that any information on the vitality of old seeds expressed in terms of the vigor and yielding power of the resulting plants would be very useful in the disposal of viable old seeds by farmers and seed houses.

The study which was undertaken at the Central Experiment Station, Bureau of Plant Industry, Manila, was started in February, 1935, and the last culture was harvested in September, 1937.

MATERIALS AND METHODS

The mungo seeds used in the four cultures made in this study were taken from the materials used first by Vibar and the writer (4), and later by the writer (3) in their study of the longevity of some farm crop seeds. The variety was the Native Yellow

[1] Read at the Fifth Philippine Science Convention (Division of Biology), February 21–26, 1939.

with dull seed coat. The seeds were 11 years and 4 months old in storage when the first culture was started.[1] The new seed, which in this case was used as check, was taken from plantings of the old seed previously made. These were done so as to be sure that the old and new seeds used in the study were of the same variety or strain; and in such an arrangement that the newly produced seeds were one month old when the cultures were made.

Four different sets of cultures were made. The first culture was made in ordinary garden plots while the other three were planted in earthen pots, which had an inside top diameter of 23 centimeters and an inside bottom diameter of 20 centimeters and a depth of 20 centimeters.

In the first culture, the seeds were first germinated in a seedbox. As the seedlings began to produce their true leaves, they were picked up carefully from the seedbox with a trowel with precaution to include practically all the roots. Each set of seeds was represented by 100 good seedlings and these were transplanted singly at 25 centimeters apart in rows spaced 30 centimeters apart. At maturity, however, each kind of seed was represented only by 56 or more plants due to some mortality in the course of their development. In the three sets of pot cultures, the seeds were directly planted in the pots, each kind of seed having been represented by 30 pots. Six to eight seeds were sown in each pot, but later the seedlings were thinned to three per pot when they had about two to three true leaves. Each set of culture was treated practically the same with respect to cultivation, spraying, weeding, and watering. At maturity, the plants were harvested, and data on the number of pods produced, weight of dry pods, weight of straw, and weight of seeds, per plant were taken.

EXPERIMENTS AND RESULTS

The results of this study are summarized in tables 1 to 4. Among other things, they show the average number of pods produced per plant, the weight of the straw and pods, and the weight of the grains or seeds. Table 1 gives a summary of the first culture, which was a rainy season culture. The stand of the plants was good. In table 2 are presented the summary

[1] The seeds were stored in bottles which were sealed with paraffin, thus making them air tight. Before storing, however, they were first dried thoroughly in the sun.

results of the second culture. This was a dry season culture; the stand of the plants was good but only few pods were produced, perhaps because of spraying in an attempt to check the growth of aphids during their flowering stage.

TABLE 1.—*Relative yields of one-month and 11-year, 4-month-old mungo seeds (first culture)*

Characters studied	New seed [a]	Old seed [b]	Difference	Significance of difference
Weight of straw [c] in gram per plant	11.36±0.55	21.86±2.03	10.50±2.33	Significant.
No. of pods per plant	9.00±0.74	17.80±1.56	8.80±1.73	Do.
Weight of pods in gram per plant	5.36±0.45	10.52±0.92	5.16±1.02	Do.
Weight of grain in gram per plant	3.23±0.31	6.83±0.78	3.60±0.84	Do.

[a] One-month old seeds after harvest.
[b] Eleven-year and 4-month old seeds in storage.
[c] Weight was taken just after harvesting the pods.

TABLE 2.—*Relative yields of new and old mungo seeds (second culture)*

Characters studied	New seed [a]	Old seed [b]	Difference	Significance of difference
Weight of straw [c] in gram per plant	1.15±0.04	1.26±0.04	0.11±0.056	Insignificant.
Weight of pods in gram per plant	1.82±0.07	2.64±0.11	0.82±0.130	Significant.
Weight of grain in gram per plant	1.33±0.05	1.73±0.06	0.40±0.070	Do.

[a] One-month old seeds after harvest.
[b] Twelve-year and 9-month old seeds in storage.
[c] The plants were already defoliated when they were cut for straw yield.

Table 3 presents the summary of the results of the third culture, which was a late dry season crop. The stand of the plants was good and so was the yield. Table 4 summarizes the results of the last culture, which was a rainy season crop. The stand of the plants was very good. These were later affected by a mild typhoon during the blooming stage.

TABLE 3.—*Relative yields of new and old mungo seeds (third culture)*

Characters studied	New seed [a]	Old seed [b]	Difference	Significance of difference
Weight of roots in gram per plant	3.20±0.14	3.65±0.19	0.45±0.24	Insignificant.
Weight of straw in gram per plant	16.00±0.44	15.20±0.52	0.80±0.68	Do.
Number of pods per plant	11.06±0.50	17.39±0.59	6.33±0.76	Significant.
Weight of pods in gram per plant	6.98±0.34	11.18±0.42	4.20±0 54	Do.
Weight of grain in gram per plant	5.33±0.27	8.38±0.29	3.06±0.39	Do.

[a] One-month old seeds after harvest.
[b] 13-year old seeds in storage.

TABLE 4.—*Relative yields of new and old seeds of mungo (fourth culture)*

Characters studied	New seed [a]	Old seed [b]	Difference	Significance of difference
Height of plant in centimeters	24.70 ±0.51	27.26 ±0.52	2.56 ±0.73	Significant.
Weight of straw in gram per plant	2.20 ±0.12	2.68 ±0.14	0.48 ±0.18	Slightly significant.
Weight of pods in gram per plant	2.58 ±0.16	2.51 ±0.14	0.07 ±0.21	Insignificant.
Weight of grain in gram per plant	1.64 ±0.13	1.58 ±0.11	0.06 ±0.17	Do.

[a] One-month old seeds after harvest.
[b] Thirteen-year and 5-month old seeds in storage.

DISCUSSION OF RESULTS

The vitality of a seed is not only measured by its ability to germinate but also very largely by its ability to produce a vigorous seedling that matures into a normal plant. In this study, the criteria that were used in the determination of the relative vitality of the new and old seeds of mungo were (1) the weight of straw, (2) the weight of pods, and (3) the weight of beans produced per plant.

Weight of straw.—From the appearance and general stand of the plants, the difference was not marked except in the first culture where the plants from the old seeds appeared to be more stocky and had more branches than those from the fresh seeds. In the weight of straw per plant, there was a great variation in the four cultures made, but it was only in the first culture (see table 1) where there was a significant difference between the vine yields of the new and old seeds in favor of the latter. The straw yields per plant of the new and old seeds were 11.36 ± 0.55 and 21.86 ± 2.03 grams, respectively. In the third culture, the old seeds produced less vine than the new seeds but the difference was nevertheless insignificant (see table 3). In the last culture (see table 4) the old seeds gave slightly heavier yield of vine.

In the weight of the root system as determined in the third culture (see table 3), while the old seeds produced heavier root system, the difference could not be considered biometrically significant. The plants from old seeds produced 3.45 ± 0.19 grams per plant of dry roots while those from new seeds gave 3.20 ± 0.14 grams per plant.

Yield of pods.—Unlike the yield of vine, there was a significant difference between the yields of pods, both in number and in weight, of the new and old seeds. In all the cultures, except the last, in spite of the great variation in pod yields, the old

seeds gave greater pod yield. In the first culture, the new seeds produced 9.00 ± 0.74 pods per plant and the old seeds, 17.80 ± 1.56 pods per plant, while in the third culture the number of pods produced per plant of the new seeds was 11.06 ± 0.50 and 17.39 ± 0.59 pods per plant for the old seeds.

Yield of beans.—The effect of the age of the mungo seeds planted on the yield of bean was similar to the effect on the yield of pod. In the first culture, the bean yields per plant of the new and old seed were 3.23 ± 0.31 and 6.83 ± 0.78 grams, respectively; in the second culture, 1.33 ± 0.05 and 1.73 ± 0.06, respectively; in the third culture, 5.33 ± 0.27 and 8.39 ± 0.29, respectively; and in the last culture the corresponding bean yields were 1.64 ± 0.13 and 1.58 ± 0.11 grams per plant (see tables 1, 2, 3 and 4). In all the cultures, except the last as in the case of the pod yield, the bean yield of the old seeds was decidedly greater than that of the new seed, the former outyielding the latter by 30 to 110%. In the last culture, however, the pod and bean yields, respectively, of the new seeds were slightly greater although the difference was negligible. It may be remarked, however, in this connection that the poor showing of the old seeds in this culture might have been due to the effect of the typhoon during the blooming period of the plants. Because of the greater height of the plants from the old seed, as shown in table 4, it is probable that the effect of the typhoon was more severe on the more vigorous plants resulting in decreased pod and bean yields.

The results thus far obtained show some strong evidence of the existence of certain phenomena in stored seeds that are worthy of conscientious and critical study. The behavior of the old seeds as manifested in this work may be explained as follows: Either the vigor (expressed in yielding power) of the seed is correlated with its inherent longevity; or the seed requires certain "seasoning" or "curing" before it is capable of attaining the peak of its vitality.

In the first case, since variation even within a pure line is universal, it may be expected that the seeds vary in their ability to keep their viability while in storage. It is probable that seeds which do not keep their viability long are not also vital. So that what seems to be accomplished in prolonged storage is that the weak and poor seeds lose their viability first and thus are naturally eliminated while the vital and productive ones remain viable.

Since the difference in yield in some of the cultures, especially the first, was so great, it appears that the difference in yield may be caused by other factors. It is also probable that the seed before it is capable of giving its best yield, goes first through a certain stage of "seasoning" or "curing" in the same way that budding or grafting requires certain definite maturity of the scion or stock before the best results can be obtained. The phenomenon which seems to cause renewed vigor or vitality is being manifested in other ways in the life of both plants and animals. For example, the writer (3) in his study of the longevity of some farm crop seeds found renewed vigor in some of the seeds he studied as expressed in the increased percentage of germination. Also, this fact was recognized by some early writers, for in 1859, Bartlett (1) reported "that cabbage, turnip seed, etc., keep well for several years, and are more to be depended on in producing those varieties in perfection than those of more recent production".

This phenomenon in the mungo seed has a far-reaching significance. For, if this holds true with other crops, the right "seasoning" or "curing" treatment may be worked out with the different crops so as to effect some increase in vigor and in production.

In this connection, it may be pointed out that the suggestion made by the writer (3) as to the possibility for "plant breeders who are testing a large number of varieties under limited means . . . . to store part of their materials to be tested gradually in later years" is not possible because of the fact brought out by this study that old and new seeds of the same variety or strain vary in their ability to develop and produce fruits or seeds.

SUMMARY

1. In this study some interesting data on the comparative vigor of new (one-month-old) and old (11- to 13-year-old) mungo seeds expressed in the yields of vine, pod, and bean were obtained.

2. The yield in straw of the old and new mungo seeds did not vary much, although it was slightly in favor of the old seeds. However, the old mungo seeds gave decidedly greater yields of pods and beans than the new seeds.

3. The results obtained show some evidence of the existence of certain phenomena in seed in storage that are worthy of a conscientious and critical study. It is strongly evident that the

seed seems to require a certain degree of "curing" or "seasoning" before it is capable of attaining the peak of its vitality. This may vary with different crops and should be thoroughly studied so as to take advantage of its economic value.

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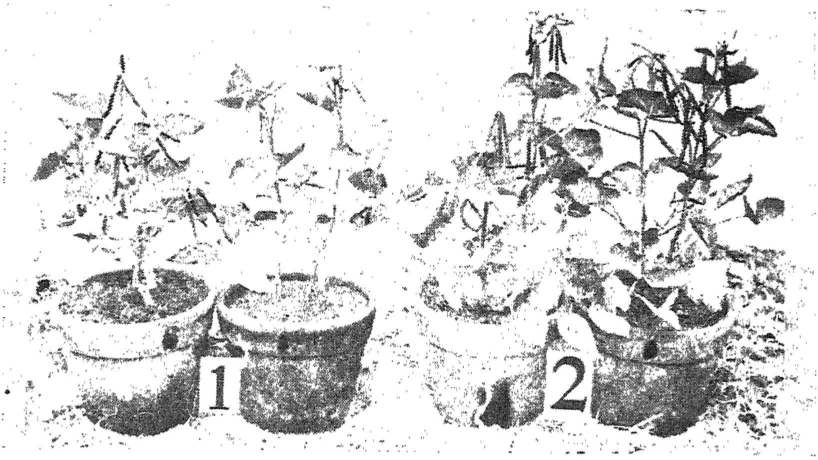
ILLUSTRATIONS

PLATE I

FIG. 1. Pot cultures (second culture) of (1) new, and (2) old seeds of mungo. The difference in stand is slight.

2. Typical plants arising from (1) new, and (2) old mungo seeds. Note the difference in size and number of pods produced.

1



2

PLATE 1.

POT CULTURE EXPERIMENTS ON CABBAGE

By JULIAN A. AGATI and P. A. RODRIGO
Of the Bureau of Plant Industry

ONE PLATE

Heretofore, the common practice of applying fertilizers to commercial cabbage cultures in the Philippines was based upon practical experience. In Baguio and Trinidad Valley, Mountain Province, where cabbage is grown not only most extensively but also intensively, the common practice is to apply a mixture of fertilizers consisting of about 6 parts of stable manure or compost, 3 parts of soybean cake and fish meal and one part of potash and phosphorous fertilizers(4). This is used as a basic fertilizer and is later supplemented with several doses of ammonium sulphate in solution [1] during the development of the plants.

Whether this is the best combination for cabbage, there are no available data to show it. Recently, however, some attempts have been made to use different brands of fertilizers, consisting of combinations of nitrogen, phosphate and potash, in cabbage culture. For example, Gutierrez(2), in his experiments, used different brands of fertilizers containing nitrogen, P_2O_5 and K_2O in different proportions. Unfortunately, in these studies, the three manurial elements (N, P, and K), were not applied singly. Neither was each element applied in the same amount. Thus, it could not be stated with certainty that the increases in yields were due to a certain element or combination of elements.

The fertilization of cabbage in the Philippines undoubtedly calls for further experimentation. One of the problems at present confronting the cabbage growers consists in finding a certain combination of two or more of the inorganic fertilizers in the market with the object in view of improving the yield and the quality of the marketable heads. The present pot culture studies aimed (1) to determine the effect of using ni-

[1] One canful (milk can, pint size) of ammonium sulphate is dissolved in one petroleum canful (20 liters) of water, and this is utilized to water about 100 to 200 plants.

trogen (N), phosphoric acid (P_2O_5) and potassium oxide (K_2O) singly at different rates on the stand and yield of cabbage, and (2) to find out the optimum amount and combinations of fertilizers of a certain standard formula which not only outyield the single fertilizer but give a quality product as well.

The study was undertaken during the vegetable season of 1937–1938 at the Central Experiment Station, Malate, Manila.

MATERIALS AND METHODS

For this experiment, 110 big earthen pots measuring 15 inches, top diameter, 12 inches high, and 12 inches, bottom diameter; sandy loam soil with a pH reaction of 6.23;[a] and seedlings of Early Flat Dutch cabbage of uniform age and size, were used.

The soil was thoroughly mixed and pulverized before transferring it into the pots. The pots were arranged in rows of eight. Excepting the first row which included only 5 pots, the other rows consisted of 15 pots, each. The first row received no treatment; it was used as a check. The second row was treated with nitrogen, the third with nitrogen and phosphoric acid, the fourth with nitrogen and potassium oxide, the fifth with nitrogen, phosphoric acid and potassium oxide, the sixth with phosphoric acid, the seventh with potassium oxide, and the last row with phosphoric acid and potassium oxide. Each of the fertilizers used was applied in three different amounts, viz., minimum, medium, and maximum. The minimum application consisted of 500 kg. of fertilizers per hectare; the medium amount was applied at the rate of 750 kg. per hectare; and the maximum rate was applied at the rate of 1,000 kg. per hectare. These rates of application bore the formula 8-12-4, that is, it contained 8 per cent nitrogen, 12 per cent phosphoric acid, and 4 per cent potassium oxide. This was found suitable under Rhode Island conditions(3). Ammonium sulphate supplied the nitrogen, superphosphate of lime the phosphoric acid, and potassium sulphate the potassium oxide. For each of the individual rates of application of the fertilizers enumerated above, five pots were used.

One seedling, about 40 days old, was planted in each pot. The fertilizers were applied one day after transplanting.

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[a] Nitrogen (N)—0.057 per cent; phosphoric anhydride (P_2O_5)—0.215 per cent; lime (CaO)—0.472 per cent; potash (K_2O)—0.097 per cent; magnesium (MgO)—1.27 per cent (analysis by R. Isidro).

Care was taken to maintain the moisture in each pot at optimum condition, that is, the soil was kept sufficiently moist so as to avoid the wilting of the plants.

The experiment was carried till harvest time. At the termination of the experiment, the height of the individual plants, the gross weight, and finally the weight and size of the marketable heads were recorded. These were used as criteria in evaluating the fertilizers employed.

The use of pot cultures seems justifiable since this method is not only less expensive and easy to handle but also gives a fairly reliable index for further experimentation in the field as found in Hawaii(1).

RESULTS OF THE EXPERIMENTS

About a week after the application of the fertilizers, their effects began to manifest themselves. All the plants that had nitrogen treatment were dark green in color and showed vigorous growth, while those that did not receive any nitrogen had poor growth, like the check plants. The plants treated with P_2O_5 and K_2O, either singly or in combination, did not produce any marketable heads. Table 1 gives the average results of the experiments while table 2 presents the summary of the results obtained.

DISCUSSION OF RESULTS

Inasmuch as the results obtained from the use of P_2O_5 and K_2O, or a combination of both, and the controls, respectively, did not yield any marketable heads at the close of the experiment, they are not considered in the present discussion. Neither the heights of the plants are taken up since they least affect the economics of the experiment. One outstanding fact derived from the results of the experiment is the apparent limiting effect of nitrogen. All the treatments in which nitrogen was included gave marketable heads. Considering first the results obtained with this treatment, it is striking to note that the total weight of heads, and the average weight of heads, respectively, were greater with the minimum application than with the maximum application. This variation may show that the practical effects of minimum rates of application are comparable to those of the maximum rates. This seems to be at variance with the findings of Rodrigo(5) that the yield was more or less proportional to the rate of ammonium sulphate applied. However, if the circumstances surrounding the experiment are to be con-

TABLE 1.—*Average results of fertilizer experiments on cabbage.*

Fertilizers used		Height of plants		Gross weight of plants		Diameter of head		Weight of marketable head		Thickness of head		Volume of water displaced		Sp. Gr.
Kind	Amount per hectare	Total	Average	Total	Average	Total	Average	Total	Average	Total	Average	Total	Average	
	kg.	*cms.*	*cms.*	*grams*	*grams*	*cms.*	*cms.*	*grams*	*grams*	*cms.*	*cms.*	*cc.*	*cc.*	
NPK	1,000	96.8	19.36	3,313.2	675.25	44.0	8.80	1,714.0	342.80	57.4	11.48	1,514.0	302.8	1.13
NPK	750	93.7	18.74	2,993.6	598.72	44.2	8.84	1,635.1	327.1	58.9	11.78	1,677.7	395.54	1.10
NPK	500	87.4	17.48	2,171.1	434.22	45.7	9.14	1,179.9	235.98	53.3	10.66	1,057.4	211.58	1.11
NP	1,000	96.9	19.38	2,934.0	586.80	42.2	8.44	1,441.4	288.28	54.20	10.84	1,091.0	218.20	1.32
NP	750	95.0	19.0	2,654.6	530.92	45.1	9.02	1,635.8	327.16	56.60	11.3	1,421.0	284.20	1.15
NP	500	90.8	18.16	2,401.5	480.30	41.5	8.30	1,424.1	284.82	53.8	10.76	1,345.0	269.00	1.05
NK	1,000	86.6	17.32	2,354.6	470.92	44.8	8.96	1,420.7	284.14	52.3	10.46	979.0	195.80	1.45
NK	750	86.6	17.32	1,984.5	396.9	41.2	8.24	1,096.6	219.32	51.1	10.22	883.0	176.60	1.24
NK	500	93.9	18.78	2,231.5	446.3	39.6	7.92	1,206.6	241.32	52.6	10.52	895.0	179.0	1.34
N	1,000	91.6	18.32	2,103.8	420.76	41.1	8.25	986.2	197.24	38.7	7.74	663.0	132.6	1.48
N	750	84.0	16.80	1,698.5	339.60	39.8	7.96	930.4	186.08	45.5	9.10	661.0	112.2	1.65
N	500	91.3	18.26	1,964.3	392.86	42.7	8.54	1,129.5	225.90	49.2	9.85	718.0	143.0	1.57
K	1,000	76.63	15.26	266.4	[a]53.28									
K	750	76.4	15.28	230.2	[a]46.04									
K	500	63.8	12.76	201.4	[a]40.28									
P	1,000	74.6	14.92	222.5	[a]44.4									
P	750	70.5	14.10	256.9	[a]51.38									
P	500	72.5	14.50	214.8	[a]42.96									
PK	1,000	73.2	14.64	302.0	60.40									
PK	750	70.4	14.08	273.4	54.68									
PK	500	70.2	14.04	216.3	43.26									
Control	[b]	74.2	14.85	243.4	[a]48.68									

[a] The plants were more or less stunted in growth and did not produce any head.
[b] No fertilizers.

TABLE 2.—*Summary results of the pot fertilizer experiments on cabbage.*

Amount of fertilizer per hectare	Criteria used	Fertilizing elements used							
		N	NP	NK	NPK	PK	P	K	Control
Kg.									
500	Average weight of plant in kg.	0.39 ±0.021	0.48 ±0.020	0.45 ±0.030	0.43 ±0.020	0.04 ±0.004	0.05 ±0.003	0.04 ±0.003	0.049
	Average weight of head in kg.	0.20 ±0.008	0.28 ±0.030	0.28 ±0.030	0.24 ±0.020				
	Percentage of heading	100	100	100	100		0	0	0
750	Average weight of plant in kg.	0.34 ±0.019	0.53 ±0.030	0.39 ±0.012	0.60 ±0.020	0.05 ±0.003	0.05 ±0.003	0.05 ±0.003	
	Average weight of head in kg.	0.18 ±0.016	0.33 ±0.012	0.21 ±0.02	0.33 ±0.015				
	Percentage of heading	100	100	100	100		0	0	0
1,000	Average weight of plant in kg.	0.42 ±0.012	0.59 ±0.020	0.47 ±0.030	0.68 ±0.020	0.06 ±0.008	0.04 ±0 003	0.05 ±0.003	
	Average weight of head in kg.	0.23 ±0.017	0.29 ±0.020	0.26 ±0 020	0.35 ±0.009				
	Percentage of heading	100	100	100	100		0	0	

sidered, these variations are rather an exception to the rule. Since nitrogen is known to be greatly soluble, it seems not unlikely that part of it is liable to be lost through leaching or splashing during rainy days. Moreover, the time of application may also affect its availability to the plants, so that when the application is not done in the most opportune time(6) the plants will not derive the whole benefit from the treatment. These two factors seemed to have been at work in the present instance.

Similarly, in the case of nitrogen and phosphoric acid, although the gross weight of heads was apparent with the maximum rate of application, the maximum average weight of the marketable heads was obtained with the medium application of fertilizers. This was also true in the case of the combination of nitrogen and potassium oxide. Thus, although the average gross weights of heads varied proportionately with the treatment, the weight of the marketable heads did not follow exactly the same trend. The minimum rate of application gave even better results than the medium rate, as shown both by the gross weights of heads and the weights of marketable heads.

Considering the results as a whole, it is evident that both nitrogen and phosphoric acid, and nitrogen and potassium oxide, respectively, gave better yields than the nitrogen alone. This shows that the addition of phosphoric acid and potassium oxide, respectively, to nitrogen produced a stimulating effect on the plants, as shown in the yield. This may also suggest the advantage of complete fertilizers. The results obtained by using a combination of nitrogen, P_2O_5 and K_2O bear out this fact. The yields obtained with the use of the complete fertilizers were generally greater than those obtained with either a combination of nitrogen and P_2O_5 or nitrogen and K_2O.

Although the results obtained from the use of NPK were generally better than those obtained from single or other combinations of fertilizers, it cannot be entirely said that its use is profitable without first considering both the production cost and the income.

There seems to be some degree of certainty that the present method of fertilizing cabbage can still be improved upon or modified by using nitrogen with P_2O_5 and K_2O in different proportions or combinations. While the production cost will undoubtedly increase, the income is bound to increase proportionately. Perhaps if a certain combination could be evolved following the trend to which the present experiments apparently lead,

and production cost could be kept at minimum levels, the culture could be made to yield returns that will give an edge to the farmer. The results from the pot cultures will constitute a fair index for further experimentation in the field. A follow-up field test will be conducted in the future.

SUMMARY

1. The present paper consists of pot culture studies using nitrogen (N), phosphoric acid (P_2O_5) and potassium oxide (K_2O) singly, and combinations of nitrogen and P_2O_5, of P_2O_5 and K_2O, and of nitrogen, P_2O_5 and K_2O applied at different rates.

2. The use of nitrogen and P_2O_5 and that of nitrogen and K_2O is better than nitrogen alone, showing the advantageous effect of combining nitrogen with these elements.

3. The treatment with a combination of nitrogen, P_2O_5 and K_2O did not only give the greatest gross weight of heads but also the greatest weight of marketable heads.

4. In some cases the yields did not increase proportionately with the rates of application of fertilizers.

5. The results obtained from the present pot culture studies gave a fair index for future tests in the field.

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ILLUSTRATIONS

PLATE 1

FIG. 1. A view of the pot cultures about three weeks after the application of the fertilizers. Note the vigor of the plants that received nitrogen treatment.

2. A view of the same pot cultures taken a few days before harvest. Marketable heads were obtained from plants that received nitrogen, either singly or in combination.

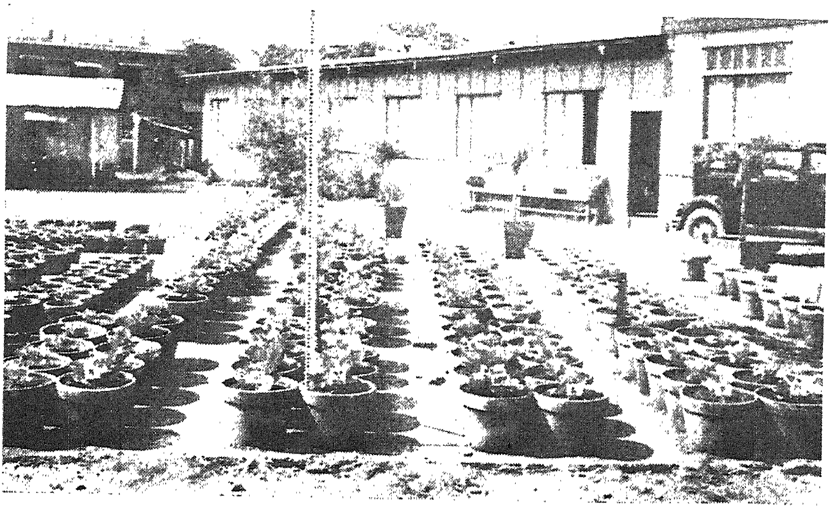

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PLATE 1.

SILKWORM CULTURE IN THE PHILIPPINES [1]

By

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and

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The Philippines import silk and its manufactures worth several millions of pesos annually. Our climate and soil are favorable to the growing of mulberry trees (*Morus alba* Linn.), and we have wide tracts of land that can be planted to mulberries. Labor is available, but it needs some training before it can tackle the different phases of silk raising. These factors, together with a comparatively small capital necessary to start it, make silkworm raising an attractive household industry.

The importation of silk and its manufactures, both natural and artificial, into the Philippines from the United States, Japan, China, and other countries is given in table 1.

TABLE 1.—*Importation of silk and its manufactures into the Philippines, from 1926 to 1937*

Year	Value
1926	₱7,092,855
1927	7,960,729
1928	8,512,739
1929	9,328,442
1930	8,650,820
1931	6,461,561
1932	4,901,256
1933	4,020,186
1934	4,603,650
1935	4,851,400
1936	5,764,409
1937	6,195,701
Average	₱6,528,645.77

[1] Farmers' Circular No. 19.

MULBERRY CULTURE

The mulberry plantation should be well established before the raising of silkworms. The plantation should not be located in a place exposed to strong winds but near the site of the silk house. Mulberry thrives in almost any kind of soil having proper drainage. Rocky or stony soil which is unfit for most economic plants may be utilized. It is generally propagated by means of stem cuttings. Cuttings 15 to 20 centimeters in length should be taken from two- to three-year-old trees and should first be planted in seedbeds prepared like garden plots or direct in the plantation at the beginning or the latter part of the rainy season. Cuttings having three or more tiny buds within the leaf axils are recommended. When the shoots are about 20 centimeters long, they may be planted permanently in the plantation. After attaining a height of one meter, they should be pruned so as to produce more lateral branches and consequently more leaves. Intercropping the young mulberries with leguminous crops is recommended as a source of additional income. Mulberries should be planted three meters apart.

SILK HOUSE

The silkworms should be raised, if possible, in a rat-proof, ant-proof and lizard-proof house. The silkhouse, like the mulberry plantation, should not be exposed to strong winds and it should be located far away from dusty roads as much as possible. Dust carries micro-organisms and is a source of infection to the silkworms. The upper portion of the walls may be made of wire gauze, screen, "sinamay" or abacá cloth used for making sacks, and the ceiling, preferably of abacá cloth which is cheaper. The lower or basal portion of the walls may be made of "sawali," plain galvanized iron, or board. The roof may be of nipa but it should be rain-proof. The legs of the racks, which hold the trays in which the worms are reared, should rest on small pans with water, or else provided with some repellant that keeps ants away from the worms. One simple method of keeping the worms away from other insects is to apply tanglefoot on the legs of the racks or wrap them around with cloth wet with petroleum or crude oil. A convenient tray for the worms is one with the dimensions $43 \times 90 \times 1.5$ centimeters with the frame made of wood or bamboo.

CULTURAL DIRECTIONS

The eggs hatch about seven to eight days after they have been laid. "The tenderest, young, green leaves which have become nearly expanded and are still of a very pale hue and which are taken from the tips of the mulberry shoots should be given at this stage, but those which are not as yet unfolded should be avoided." The leaves should be placed within the reach of the larvae. The newly hatched larvae crawl and feed on the leaves. The leaves with the young worms are transferred to other trays. Then they are given the proper feeding by distributing thinly chopped mulberry leaves over them. If the leaves are too dry, they should be changed. As the larvæ grow older or bigger they should be given older leaves. The best rule to follow is "age of leaves to the age of silkworms." Plate 3 shows the age of leaves to be given to the worms at different instars. The larvæ should not be touched with the fingers but with a soft hair brush or a pair of fine-pointed bamboo pincers.

From four to six feedings at intervals of three hours are required daily from 6 o'clock in the morning to 6 o'clock in the evening. Dead larvae and decaying feeds should be removed immediately and before fresh feeds are given, otherwise they might cause an epidemic to the worms. Changing of beds where the excrements and the unconsumed feeds accumulate should be done daily especially during damp weather.

While the larvae are molting they should not be given any feed. The signs of molting are a "cessation of feeding, a general appearance of fullness, an elevation of the forward third of the body, a drawing together of the forward three pairs of legs, the assuming of the sphinx-like attitude, and the extremely small size of the head as compared with the rest of the body." The space occupied by the worms is doubled after each molting. The worms should be grouped according to age or size. Smaller worms resulting from poor development or late molting should be removed and grouped or placed separately.

In the fourth and fifth instars, the worms may be fed with "fully matured leaves, not hard, dry leaves which are on the verge of dropping from the plant, but fully expanded, dark-colored, glossy leaves of a rough feel, and which are free from sand, dust, and mold."

34343——7

At the fifth instar, the body of the silkworm is plump, buff grayish white, turning to a translucent yellow, a day or two before it begins to spin. "A silkworm first indicates that it is about to spin by ceasing to eat, protruding its head, and beginning to reach around as if looking for something." When the worms show these signs they are ready to spin and may then be brought to the spinning place. The spinning place may be of wire baskets or a box containing suitable materials for pupation. Dry grass, cogon leaves, rice straw, abacá tow or similar materials are arranged loosely in the box or wire baskets for the spinning place.

Three days after the pupation, the cocoons may be taken out and the best ones are selected for further breeding purposes while the rest may be reeled at once and used for spinning silk. The earliest cocoons are reserved for breeding purposes. A good rule to follow is to select "twice as many large cocoons as desired for females and the same proportion of small- and medium-sized ones in order to get a fairly large number of males." If the cocoons are to be kept for shipping or if they cannot be reeled immediately, they must be killed by steam or dry heat (sun drying).

The cocoons for reproduction are pasted to a tray lined with Manila paper or abacá burlap or buri raffia mat (*dait*) to keep them in place. When the moths emerge, they should be isolated in order that copulation may be controlled.

Only the most vigorous females and those having the largest abdomen should be selected for egg reproduction. The males which are energetic and have perfect bodies and wing formations should be used for breeding purposes. When the wings of the moths are thoroughly dry, copulation for two hours is necessary to insure fertilization of all the eggs. After copulation, the females are placed singly on a small piece of paper and a ring of bamboo or cardboard two to three centimeters high is put around to protect them while laying eggs.

PRESERVATION OF COCOONS

Cocoons should be thoroughly dried before storing them for the market. They should be protected from ants. The simplest method of storing the cocoons is to place them in thin tin vessels with tight fitting covers. In large scale storing, the dried cocoons are placed in bags of thick moisture-proof paper.

LIFE HISTORY

The following data on the life of the Bengal-Ceylon silkworm were obtained at the Central Experiment Station, Manila, by the Entomology Section, Plant Pest and Disease Control Division:

Egg stage	7 to 8 days
Larval stage	10 to 24 days
Molts, four times	
1st Instar	3 to 4 days
2nd Instar	3 to 4 days
3rd Instar	3 to 4 days
4th Instar	3 to 5 days
5th Instar	5 to 7 days
Spinning of cocoons	About 2 days
Pupal stage	8 to 10 days
Adult stage	2 to 5 days
Female moths lay eggs about 12 hours after emergence	
Number of eggs laid by each female	300–450
Life cycle (egg to adult)	38–45 days
Number of generations in one year	8–9

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ILLUSTRATIONS

PLATE 1

FIG. 1. Silkworm cocoons.
2. Pupae inside the cocoons.

PLATE 2

FIG. 1. Copulating moths.
2. Eggs.

PLATE 3

Mulberry leaves of different stages for the larvae of different instars.

PLATE 4

FIG. 1. A tray where worms are reared.
2. A rack where the trays are placed.

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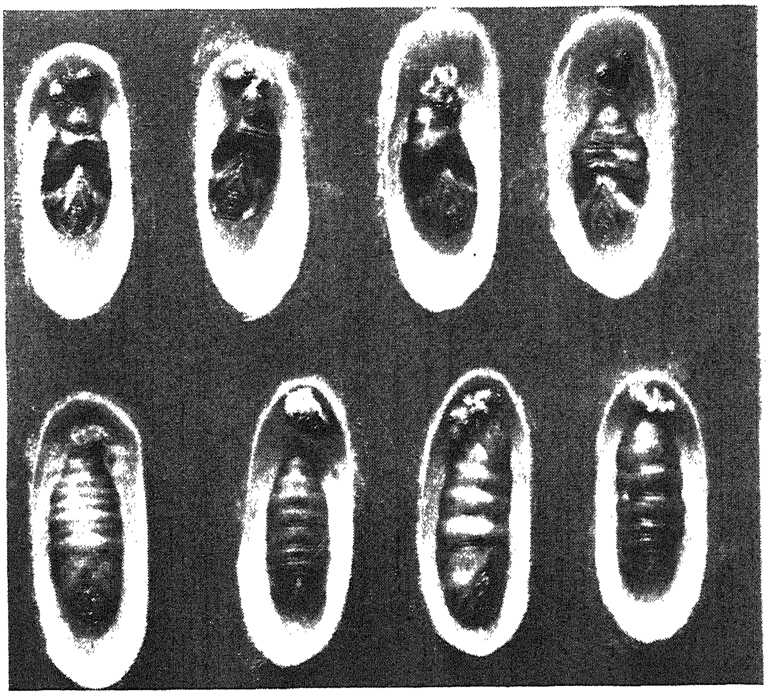

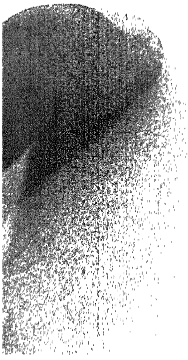

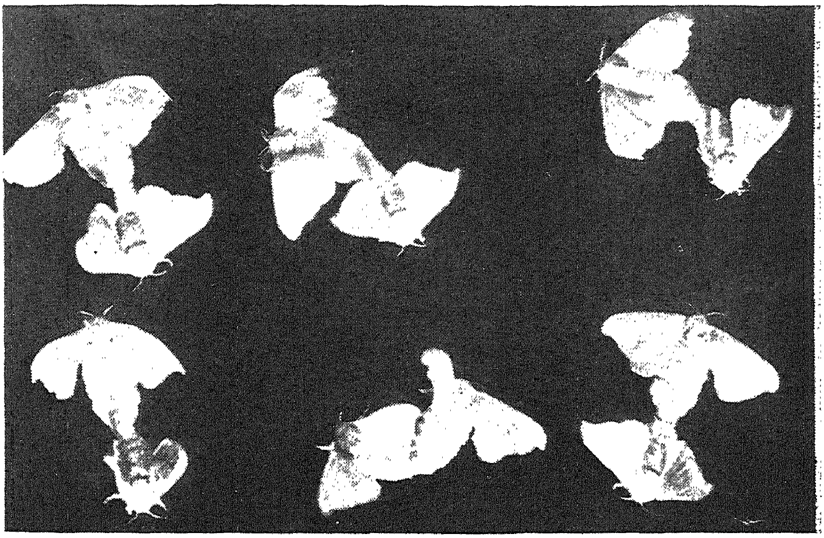

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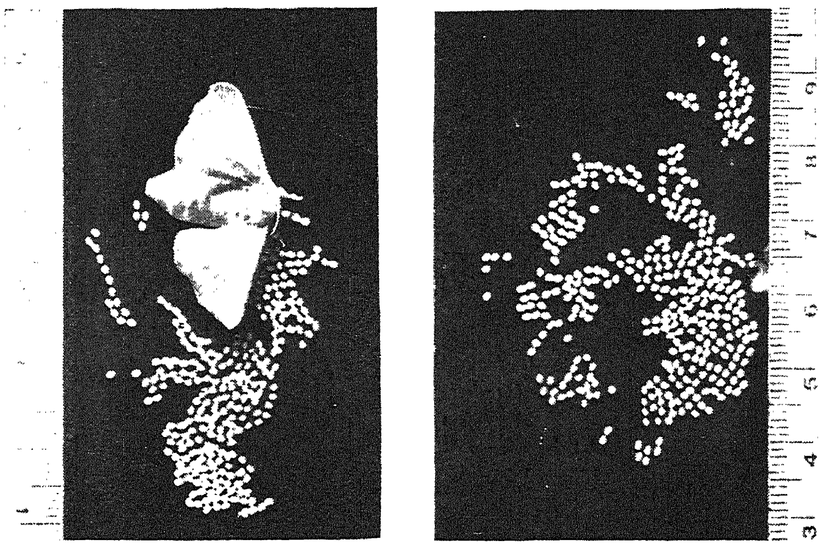

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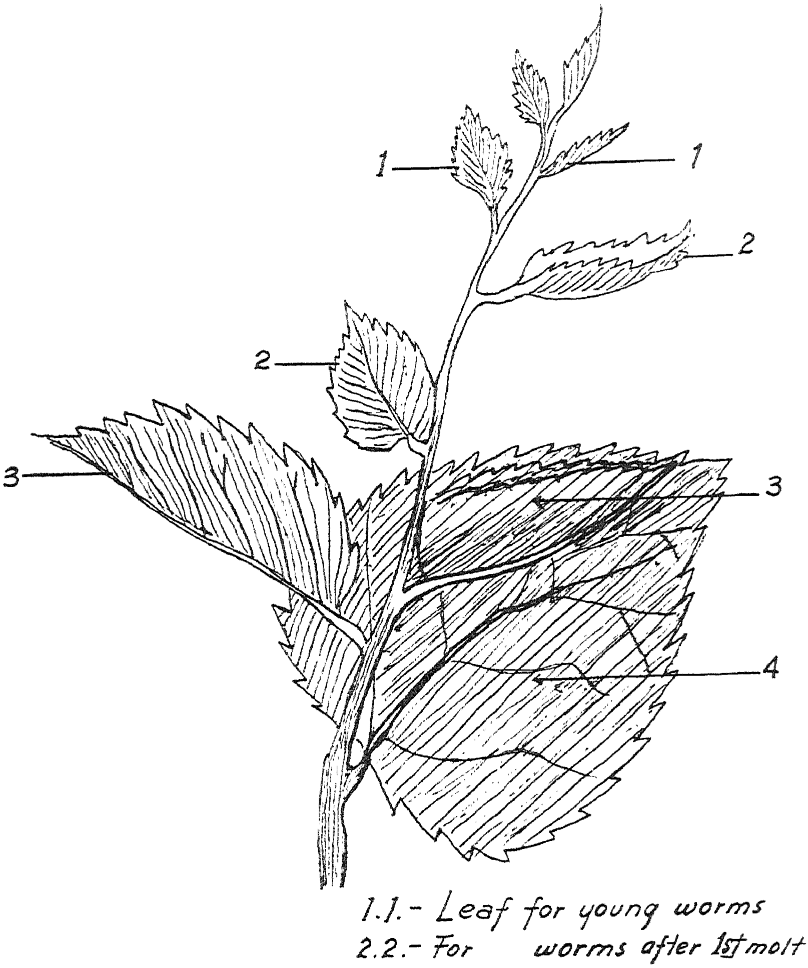
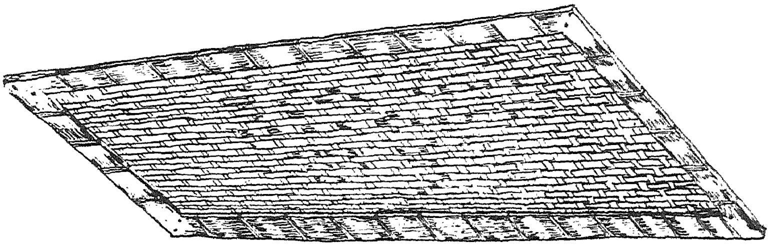
PLATE 2.



1.1.- Leaf for young worms
2.2.- For worms after 1st molt
3.3.- " " " 2nd "
4.- " " " 3rd "

After Percy N. Braine

PLATE 3.



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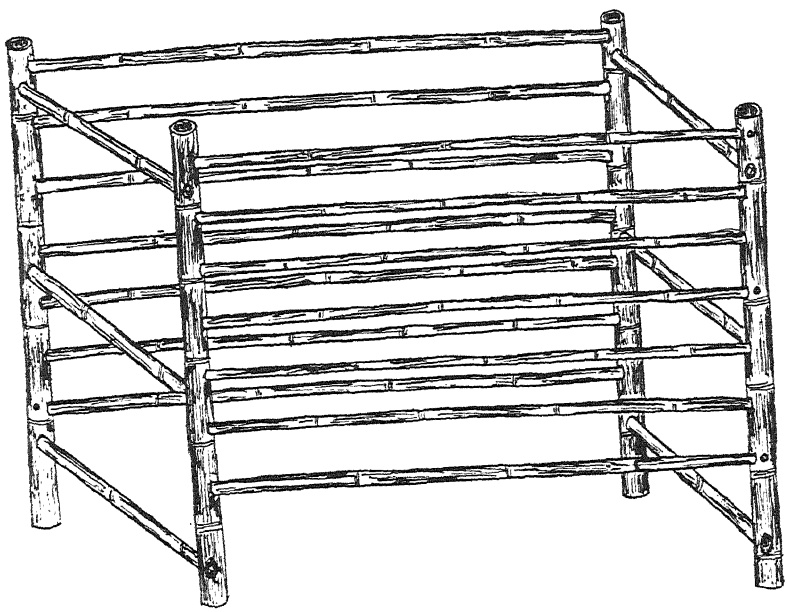

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PLATE 4.

BATEK LEAF TOBACCO CULTURE IN THE PHILIPPINES [1]

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and

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Choice of varieties.—Any good variety for cigar filler is also good for batek production. The Vizcaya, Simmaba, and Marogui, however, are the best suited for batek culture because of their size.

Soil requirements.—Sandy loam soils which are exceedingly fertile and well-drained are ideal for batek culture.

Climatic requirements.—Regions with well-defined dry and wet seasons like La Union and Pangasinan are the principal batek-tobacco-producing provinces. However, Laguna with short dry period has been proven to grow good-quality batek. This being the case, even the Cagayan Valley might be suited for batek culture.

The optimum seasonal periods of field operations for batek tobacco are the same as those for wrapper culture, viz.:

1. Sowing of seeds	October 1–15
2. Transplanting	November 25 to December 15
3. First harvest (liso)	January 25 to February 5
4. First harvest (batek)	February 25
5. Curing period	30 to 45 days
6. Number of harvests (priming)	4 to 5 times

The above schedule of field operations is applicable under La Union, Pangasinan, and Laguna conditions, and in places with similar climatic conditions.

Location and preparation of seedbeds.—Well-drained, loamy and fertile sections of the field near a good water supply should be selected for seedbed purposes. The ground is plowed and harrowed thoroughly in September and October and after-

[1] Farmers' Circular No. 18.

wards divided into plots each with an area of one meter by ten meters. The plots should be laid lengthwise from north to south instead of from east to west. A path of about half a meter wide should separate the plots. These paths will serve as drainage and passageways. The soil dug from the path should be deposited on the plots thus formed to elevate them. Each bed is provided with an inclined portable shed to protect it from strong rain and sunshine. For covenience, the shed should be a meter high at the front and about sixty centimeters at the rear in order to admit the morning sun into the beds, but not the afternoon sun. The most suitable materials for seedbed sheds are bamboo for frame, and talahib, cogon grass, nipa shingles or abacá cloth for shed cover.

The final preparation of the seedbeds preparatory to sowing should be aided by the use of garden tools like the rake and the hoe. The debris is removed and the soil is well pulverized and leveled accordingly by making the edges of the beds a little higher than the center.

Sowing of seeds.—Sow only seeds of high viability. This can easily be determined by germinating a few seeds between pieces of moist blotting paper and then counting the number of seeds that germinate and those that fail to germinate. If the percentage of germination is not lower than seventy per cent then the seed is still good for sowing. For every bed of one meter by ten meters, five grams of seed is sown. This amount can be placed in two-thirds of a one-centavo match box. The seed is mixed with two chupas of well-sieved wood ash as the seeds are hardly visible. The evenness of the wood ash over the beds is a direct indication of the even distribution of the seeds.

A bed of the size mentioned above will produce no less than a thousand seedlings, so that ten beds will be about enough to provide seedlings for a hectare of batek tobacco.

Newly sown seeds are frequently attacked by ants. To protect the seeds from being carried away by ants, it is well to scatter sweetened ground corn as bait around the borders of the beds.

Care of seedlings.—After the seeds are sown the surface of the beds is made firm by the use of a wood plank. This will keep the seeds from being blown or from being washed out during watering. The beds should be kept moist every day but not damp. The seedlings will come up within seven to ten days. Newly germinated seedlings should not be disturbed until they

have two pairs of leaves. When the seedlings reach this stage then weeding can be started and done every now and then to keep the beds free from weeds. Crowded areas should be thinned out by pulling some of the seedlings. The damping-off is a frequent disease in the seedbed. When this disease occurs, the infected seedlings, including the soil, should be removed, and the infected area treated with 5 per cent formaline solution.

Fifteen to twenty days after germination the shelter of the beds can be removed to allow the seedlings to grow in the open. This will make them sturdy and thus easily recover when transplanted in the field.

Preparation of the field.—The field is first cleared of bushes. stumps and weeds before it is plowed and harrowed thoroughly crosswise until it is well pulverized. One day before transplanting, the furrows are laid about a meter apart. Then cross furrows are laid eighty centimeters apart. The native plow is very appropriate for laying the furrows.

Transplanting.—Forty-five to sixty days after sowing, the seedlings will be ready for planting. The seedbeds are sprinkled with water to soften the ground before the seedlings are pulled. This will lessen the breakage of the root system. Only uniform and healthy seedlings should be utilized for transplanting. A hole sufficiently deep to accommodate the entire root system of the seedling is dug at the intersection of the furrows. The seedling is laid carefully in the hole standing upright while the roots are covered with soil. This done, the newly transplanted seedling is watered to have an easy start.

Cultivation.—Cultivation begins as soon as the plants have fully recovered. The first cultivation is done with a trowel by loosening the ground around the plants and heaping the soil around the stem. This method of cultivation is done regularly until the plants are about a foot high. Then the plow is used next by passing it between the rows and turning the soil over along the row, gradually converting the rows of plants into ridges. Two to three plow cultivations besides the first hand cultivation usually are sufficient. By the time the last plow cultivation is completed the plants will then have from eight to twelve leaves.

Worming.—From the time the plants are set in the field worm-picking becomes a daily routine job in the plantation. The worms are the most destructive enemy of the tobacco in the

field. The batek, being a fancy crop, should be free from any unsoundness. In cigar filler and wrapper tobacco production, the use of arsenical mixtures for worm control is often resorted to. In batek tobacco production the use of same is not indispensable. Hand picking is more efficient specially when the plants are already topped.

Topping and suckering.—Topping is done when the plants have developed eight to twelve leaves by pinching the bud. The plant, being still very young and at its most vigorous stage of growth, naturally nourishes the remaining leaves. Suckers which invariably follow topping should be removed as fast as they appear to insure maximum development of the leaves.

Harvesting.—The sand leaves are harvested as *liso* (cigar filler) tobacco and are usually primed after the last cultivation. Batek leaves ready for harvest, however, should bear the characteristic brown spot which means that the leaves have reached full ripeness. The appearance of the spot is gradual, appearing first as faint yellowish coloration and becoming more pronounced as the leaves mature and turning eventually into brown, lifeless spots in the leaves. Usually two leaves are picked every priming. The leaves are brought to the curing barn and classified as to length preparatory to sticking. Harvesting is done in the morning so that sticking can be performed during the hot hours of the day. After all the batek leaves have been harvested the plants are allowed to develop suckers for the further production of *liso* tobacco.

Poling or sticking.—The sand leaves which are *liso* (cigar filler) tobacco are sticked or poled as the ordinary cigar filler crop, but the batek leaves are poled in an entirely different manner. The batek leaves are stuck by passing the sharpened end of the palillo through the petiole of the leaf. This is done in such a manner that the leaves are placed back to back with their upper surfaces exposed. Strong sticks (palillos) should be used as the leaves are big and heavy. The stuck tobacco are placed on the racks ready to cure.

Curing shed and the curing operation.—A good curing barn for cigar filler or cigar wrapper tobacco is also good for curing batek tobacco. The ordinary practice of wilting the cigar filler leaf tobacco in the sun is dispensed with in the case of batek tobacco. Good ventilation should be provided as the crop is cured purely by the action of air. The barn should be closed during the first three to five days of curing, and gradually opened

thereafter, until the leaves and midribs are thoroughly dried or desiccated. Curing lasts from 30 to 45 days, depending upon weather conditions and the size and thickness of the leaves. The crop is completely cured when the midrib, which dries last, is free from sap.

Bunching and fermentation.—Thoroughly cured leaves are taken down from the racks early in the morning, removed from the palillos and assorted as to size. After sorting, the leaves are ready to be bunched or made into hands. A small stick about a foot long is passed through the holes of the petioles of 20 leaves with their laminae spread flat and overlapping each other. Five of these small palillos are then piled one over the other to form a hand of one hundred leaves. The hand is tied with buri leaf strips at the basal, middle, and apical regions, after which it is ready for storage in big boxes for fermentation and aging processes.

Preparation of product for market.—A month or two after storage the crop is ready for sale. If the crop is sold as a whole, the transaction would be on the quintal basis and buyers would base their offer on the estimated percentage of big-sized hands present in the whole lot or *partida.* If the percentage of big-sized hands is high better prices are offered. If the crop is sold by the hand or even by the leaf, the big hands or leaves command higher prices. Batek tobacco commands a much higher price than the cigar filler type. The characteristic spots of batek tobacco do not really play an important role in its sale. What is most important is that it should be thick and strong. Incidentally, cigar filler tobacco leaves are obtained from the sand leaves and suckers of batek tobacco which are, as a rule, of medium texture.

ERRATA

THE GRANJA SUGAR CANE EXPERIMENT STATION, by Juan B. Cabanos, Vol. 10, No. 1:

Page 38, third paragraph. Substitute the following statement: "The West Negros district is seldom visited by destructive typhoons and, therefore, rarely receives the hazards of destructive storms and floods."

Page 38, Table on rainfall and meteorological readings, column 4, line 2. Read *117.13* instead of *17.13*.

Supra, line 3. Read *109.79* instead of *9.79*.

Supra, columns 5, 6 and 7, omit.

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COTTON PESTS IN THE PHILIPPINES[1]

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Bureau of Plant Industry

THIRTEEN PLATES

In 1935, the writers published a preliminary paper on cotton insects in the Philippines with suggestions for their control. Since then additional data have been obtained which justify the publication of a bulletin in an effort to meet the demand for information on cotton pests and their control. This is deemed timely because of the encouragement being given to cotton growing with the object of supplying the ever-growing demand for the fiber for various local textile industries. Insect pests, in particular, constitute an important factor to contend with in cotton growing and cotton, being a dry season crop, its culture coincides with the abundance of some of the most important insect pests, particularly the local boll weevils, bollworms, plant lice, leaf hoppers and mealy bugs. The cotton planter should be familiar with at least the most important pests of cotton, their life histories and habits and the methods of preventing serious infestations by these pests.

In the control of cotton pests, every method possible should be employed. Along with the use of insecticides, the importance of mechanical methods of control, such as hand-picking,

[1] To be reprinted as Department Popular Bulletin No. 13.

should not be underestimated, especially in places where labor is cheap, for, when these methods are timely and persistently employed, the damage by certain pests, such as the boll weevil, can be greatly minimized. Due attention should also be given to the proper culture of the cotton plant, as this has much to do with the incidence of certain insects. Among the factors to be considered are the most suitable varieties or strains of cotton to plant, right time of planting, proper tillage and such other practices that will tend to conserve soil moisture, for lack of water makes the plants stunted and thus become susceptible to the attack of insects, particularly sucking insects.

BITING INSECTS

THE COTTON BOLL WEEVIL

(*Amorphoidea lata* Motsch.)

(Plate 1, figs. 3, 4, and 5)

Habits and descriptions.—This is probably the most destructive biting insect on cotton. Its work is similar to that of the notorious Mexican boll weevil (*Anthonomus grandis*) in the United States. The insect is dark brown and is from 3 to 4 millimeters long. As the name indicates, the insect is with a snout or beak at the end of which are the teeth and mandibles and other mouth parts.

At the Central Experiment Station, Singalong, Manila, the insects have been observed to gather in the newly opened flowers in the morning, usually between 7 and 10 o'clock, to feed and to breed. When ready to lay eggs, the female excavates a small cavity in the tissue of the base of the staminal sheath with its snout, and then reversing its position, deposits a single egg in this cavity (plate 1, fig. 1. See also plate 9, fig. 1). The eggs are smooth, pearly white, elliptical to ovoid, each measuring about 0.6 millimeter long and 0.4 millimeter in diameter. Several eggs may be deposited in a flower. An average of 5 eggs per flower has been found.

The larvae or grubs are wrinkled, grayish white, crescent-shaped, apodous or legless. A full-grown grub measures about 4 millimeters long and 1.2 millimeters at its greatest diameter. These larvae eat the ovules and other soft parts of the square. Because of this injury, the young bolls soon fall off to the ground (plate 1, fig. 2). As many as five larvae or grubs have been found in a fallen boll, which they soon leave to pupate in the

soil. The pupae are white, naked and resemble the adults as to form.

Life history.—Woodworth (1922) found out that the life history of the insect under conditions at the College of Agriculture, Los Baños, Laguna, was as follows:

Incubation period	1 to 3 days
Larval stage	5 to 9 days
Pupal stage	3 to 5 days

The life cycle, as given above, therefore, from the time the eggs were laid to the time the adult beetles emerged, was from 9 to 17 days, the average being 11.8 days.

The same author found out that the insect also bred in the flowers of a tree known in Tagalog as "makarapas" (*Thespesia lampas*) and that the beetles fed on the flowers of other plants related to cotton.

The life history of the insect as observed by the writers in the Entomology Laboratory in Manila are as follows:

Incubation period	2 to 3 days
Larval or grub stage	6 to 11 days
Pupal stage	2 to 5 days
Emergence to first laying of eggs	1 to 4 days

From the preceding data, the life cycle of the insect in Manila, from the time the eggs are laid to that when the adults begin to lay eggs, is from 11 to 23 days or an average of 17 days.

Control.—Since the full-grown grubs pupate in the soil, it is advisable that the fallen bolls be collected promptly every day and burned so as to prevent the pest from increasing rapidly.

Since the beetles congregate or gather in the newly opened flowers, as many as over thirty having been found in one flower, they should be collected and killed. If this is done persistently, especially when the early flowers appear, the damage can be greatly minimized.

The writers found out that dusting the beetles which congregated in the newly opened flowers in the morning with a 50–50 mixture, by volume, of calcium arsenate and "gaogao" killed the beetles in about half an hour. The same result was observed with derris powder mixed with an equal weight of "gaogao". These two insecticides may, therefore, be used especially on the early flowers that may be infested during the season. Dusting should be done at least three times a week, at about 10 o'clock in the morning so that the adults which sleep

in the older flowers have enough time to transfer to the newly opened flowers.

As to the natural enemies, only the bug (*Geocoris tricolor*, plate 10, fig. 5) has been found to prey on the weevils as well as on the mealy bugs (*Ferrisia virgata*).

THE BOLLWORMS

The caterpillars that attack the bolls of cotton, of which there are at least three species (Butac, 1938), are as important as the local cotton boll weevil. One of them, the pink bollworm (*Pectinophora gossypiella*), which is tropicopolitan, has been reported at one time, to be quite destructive in La Union. This is widely distributed in the Philippines, having been observed in the Ilocos provinces as well as in northern Mindanao by the writers. In other countries, as in Brazil, Egypt, and Mexico, the pink bollworm is known to be the worst pest of cotton, causing heavy losses in yield of both lint and seeds, amounting to millions of dollars. In the United States, the insect threatens to get established in the cotton belt. The United States Government spends hundreds of thousands of dollars annually for the quarantine and eradication of wild cotton (Hunter, 1918 and Curl, 1938). In the Coimbatore District, in south India, the pest is also said to be serious. In 1919, it was proclaimed, among others, as a pest under the Agricultural Pests and Diseases Act (Ballard, 1921). According to Wardle (1929) the pink bollworm disputes with the boll weevil (*Anthonomus grandis*) in America, the distinction of being the most destructive cotton pest in the world.

The two other species of bollworms (*Earias* spp.) otherwise known as "spiny bollworms" in Egypt, and "spotted bollworms" in India, certain species of which are found in the Philippines, are no less serious than the pink bollworms.

THE PINK BOLLWORMS

(*Pectinophora gossypiella* Saund.)

Injury and habits.—In the Entomology Laboratory at the Central Experiment Station, Manila, the female was observed to lay eggs during the night. The eggs were found laid on various parts of the plant as on the bolls, squares, flower buds and underneath the leaves when portions of the branches of the plant containing these parts were introduced into the breeding jar. Both sexes were inactive during the day. They were observed to hide most of the time between the lumps of soil at the bottom of the breeding jar.

The newly hatched larvae were observed to feed temporarily on buds or flowers and to transfer later to the bolls which provided abundant food for them (plate 3, fig. 3). They remained in the bolls to pupate. Before pupation they were observed to make exit holes through which they emerged when they became adults. Infested bolls matured abnormally and the lint was found to be short, colored, kinky, and weak and the seeds (plate 3, fig. 2) were of poor quality.

It was also observed that some of the larvae which were picked with the crop during harvest enclosed themselves by fastening together two hollowed seeds (plate 3, fig. 1). These were the larvae that would pass through a rest period or aestivation, the longest period observed so far in the Entomology Laboratory at the Central Experiment Station, Manila, being from 6 to 9 months. In Egypt, according to Gough (1921), a moth was found to emerge from double seeds received from India after two and one-half years. As was observed in Manila in 1935, larvae in cotton bolls were not destroyed during the ginning process. Therefore, when the seeds for the next planting season are stored, the larvae are stored with them, these emerging later as moths when conditions become favorable (Richard, 1924).

While some of the larvae of the later generations go to a state of aestivation, there are those that continue their life cycle by breeding on wild cotton and on the cotton plants left in the field. On several occasions during the off season for cotton in 1936, in the Central Experiment Station, Singalong, Manila, the junior author collected larvae and pupae of the insect from the cotton tree, *Gossypium arborium,* as well as from cotton plants left growing in the field during the time. So it can be readily seen that there are two sources of infestation for each year's crop, namely, from adults that emerge from larvae that aestivate, and from those that develop from volunteer plants and from those that are left in the field. Infestations may also come from growing perennial varieties of cotton plants.

Life history.—The life history of the insect as observed in the Entomology Laboratory in Manila was as follows:

Incubation period	4 to 6 days
Larval stage	14 to 25 days
Pupal stage	5 to 9 days
Emergence of adult to first oviposition	2 to 7 days

From the preceding data the life cycle in Manila, therefore, from the time the eggs were laid to that when the adults began to lay eggs was from 25 to 47 days, the mean being 30.9 days.

The period of fecundity varied from 6 to 10 days, with an average of 8 days. The average number of eggs laid daily by a female ranged from 3 to 74 or an average of around 27 eggs. The total number of eggs laid ranged from 194 to 234 eggs with an average of 219 eggs. Adults in confinement were found to live from 7 to 25 days or with an average of 14.8 days.

Description.—The following are the descriptions of the different stages:

The eggs (plate 2, fig. 2).—The eggs are small, elliptical, about 0.5 millimeter long and 0.3 millimeter in diameter, pearly white and are finely reticulated. About a day before hatching, the eggs turn faint orange with a distinct darker shade at one end, indicating the head of the developing embryo.

Larval stage (plate 2, fig. 3; also plate 9, fig. 5).—The newly hatched caterpillar is about 1 millimeter long, yellowish and with a dark brown head. As the larva grows, it becomes pink in color, hence the name, and the weak pale yellow hairs or setae scattered all over the body become more prominent. A full-grown larva measures about 1.2 centimeters long and 2.5 millimeters wide.

Pupal stage (plate 2, fig. 4; also plate 9, fig. 6).—The pupa is orange to reddish-brown in color turning conspicuously darker after about a day before the moth emerges. It is rather densely covered with setae, some of those at the caudal end being distinctly longer and larger and are hooked at the end. The length and diameter are about 9 and 3.8 millimeters, respectively.

Adult stage (plate 2, fig. 1; also plate 9, fig. 7).—The female moth is small and slender. It is about 7 millimeters long from the tip of the head to that of the abdomen and the wing expanse is about 15 millimeters. The color is gray to somewhat dark brown. The fore wings are rather acutely pointed and are fringed with setae along the apical margins. The hind wings are somewhat broader and are more acutely pointed than the fore wings. The sexes are similar in size and appearance.

THE "SPOTTED BOLLWORMS"

(*Earias fabia* Stoll.)

Injury and habits.—The adult insects are nocturnal. The female was observed to lay eggs during the night only, laying

these singly on or near the terminal buds, and sometimes on the bolls and flowers.

The larvae were observed to appear in the cotton fields before the plants were in bloom. At this stage of the growth of the plants the larvae bore into the stems and branches of the plants from the buds, thus destroying the main shoots and branches which potentially bore the flowers or bolls (plate 4, figs. 1 and 2). Between 9 and 12 o'clock in the morning they were observed to wander from one branch to another, as if in search of a suitable branch to bore into. When flower buds, flowers and bolls were already present, the caterpillars appeared to show a decided preference for these; hence, perhaps, the name "bollworm."

The caterpillars hollow out the flower bud or completely eat all the contents. If it is an open flower which is attacked they simply destroy the anther and then leave it in preference to the bolls. A very good indication of the presence of larvae in the bolls is the fresh excrement passed out through the entrance hole which may be seen projecting out from the side of an infested boll. The exit holes are located at the bases of the attacked bolls (plate 4, fig. 3). Once the larvae are inside the bolls, they destroy the seeds and incidentally damage the lint. When they are ready to pupate they come out of the boll to spin cocoon. It takes the larvae about a day to complete the work. During this period they cease to eat. The cocoons are attached to either the petioles and branches of the plant or to the bracts of the bolls.

Life history.—The life history of the insect as observed in the Entomology Laboratory in Manila was as follows:

Incubation period	2 to 4 days
Larval stage	11 to 17 days
Pupal stage	8 to 11 days
Emergence of adult to first oviposition	2 to 5 days

As shown above, the life history of the insect in Manila, from the time the eggs were laid to that when the adults began to lay eggs was from 23 to 37 days, the mean being 29.4 days.

The periods of fecundity varied from 8 to 22 days with an average of 13.3 days. The number of eggs laid daily by a female ranged from 1 to 73, with an average of 19 eggs. The total number of eggs laid ranged from 91 to 327 eggs, or an

average of 239 eggs. The adults were found to live from 3 to 28 days in confinement, or an average of 17.5 days.

Descriptions.—The descriptions of the different stages are as follows:

The eggs (plate 2, fig. 8).—The eggs are small, almost round, about 0.4 millimeter in diameter, green, reticulated, with projections or protuberances at one pole.

Larval stage (plate 2, fig. 6).—The newly hatched larva is about 2 millimeters long, the head being darker than the rest of the body, which is light brown. The full-grown larva is about 16 millimeters long, of a purple color, and the back is spotted with white. Because of these white spots the caterpillar has been called "the spotted bollworm," in India. Both lateral sides and portions of the back near the head and near the posterior end are tinged with orange. The dorsal and lateral sides of the larva are provided with short strong hairs or setae; hence the caterpillar is sometimes called "spiny bollworm."

Pupal stage (plate 2, fig. 7).—The cocoon which encloses the pupa is boat-shaped and the color varies from faint yellow to light brown. The cocoon is small, measuring about 9 millimeters long and about 4 millimeters at its greatest width. The anterior end of the cocoon is loosely woven, which condition facilitates the emergence of the adult.

Adult stage (plate 2, fig. 5).—The adult female is about 8 millimeters long from the tip of the head to the tip of the abdomen and the wing expanse is about 20 millimeters. The antennae are covered by the wings most of the time when the moth is in its natural resting position. The fore wings are pinkish-yellow, and each has a longitudinal triangular green streak in the middle, and is fringed with setae; head greenish-white, like the thorax, except the middle part, which is greenish. The palpi, antennae, legs and abdomen are yellowish. The adult male is about the size of the female and is of the same appearance.

Earias chromataria Wlk.

Injury and habits.—The adults (plate 2, fig. 9) are nocturnal. The female was observed to lay eggs singly on or near the terminal buds and sometimes on the bolls and flowers of cotton.

The caterpillars (plate 2, fig. 10) bore into the stems and branches of the young cotton plants from the buds. After they exhaust the soft portions they transfer to other shoots or

branches. But like the caterpillars of *E. fabia,* they show a decided preference for the flower buds, flowers and bolls.

The caterpillars hollow out the flower bud or completely eat all the contents. If they happen to attack an open flower, they simply destroy the anther. When caterpillars are inside the bolls they feed on the seeds and in so doing they also cut the lints. The presence of caterpillars in the bolls can be detected by the fresh excrement projecting out from the side of the bolls near the entrance hole. As soon as the larvae are ready to pupate they come out of the boll and begin to spin their cocoons, and this takes them a day to complete. The cocoons are attached to either the petioles and branches of the plant or to the bracts.

Life history.—The following records of the life history of the insect were taken in the Entomology Laboratory in Manila:

Incubation period	4 days
Larval stage	20 to 21 days
Pupal stage	7 to 12 days

The period, therefore, from the time the eggs were laid to that when the adults began to emerge, was from 31 to 37 days, the mean being 34.7 days.

Descriptions.—The following are the descriptions of the different stages:

The eggs.—The eggs are small, almost round, about 0.4 millimeter in diameter, green, reticulated and with projections or protuberances at one pole like those of the eggs of *E. fabia*.

Larval stage.—The newly hatched larva is about 2 millimeters long, the head being darker than the rest of the body, which is light brown. The full-grown larva is light gray, about 16 millimeters long and the back is spotted with dull white. The dorsal and lateral sides of the larva are provided with short strong hairs or setae like those of the larva of *E. fabia*.

The pupal stage.—The cocoon is boat-shaped like that of *E. fabia*. The color is light brown and is attached to either the petioles and branches of the plants or to the bracts. The cocoon measures about 9 millimeters long and about 4 millimeters at its great diameter.

Adult stage.—The adult female is about 7 millimeters long from the tip of the head to the tip of the abdomen. The wing expanse is about 17 millimeters. The fore wing is bluish-green with reddish-brown spots and is fringed with purplish-brown hairs. The base of the wing is reddish. The head is yellowish-

green and tinged with red and the bases of the antennae are reddish. The legs are white and also tinged with red. The male is about the size of the female and the color pattern is similar.

CONTROL MEASURE SUGGESTIONS FOR THE BOLLWORMS

Pink bollworm.—The bolls that mature early should be carefully examined and those found attacked should be gathered and fumigated with carbon bisulphide or with a mixture of ethylene dichloride and carbon tetrachloride.

The junior author observed in the barrios of Labagan, San Lorenzo, and Santa Rosa of San Nicolas, Ilocos Norte, that on the first and succeeding pickings (bucag) of matured bolls, the farmers separated the good floss from the seeds and bracts leaving the infested floss and seeds with the broken bracts, which were just thrown to the back yard near cotton fields. The full-grown larvae present in these discarded materials either go through a period of aestivation or pupate and become adults, and then fly to the fields thus increasing the infestation during the cotton season. Discarded floss and seeds should not, therefore, be carelessly thrown out but burned.

It is also suggested that after harvest, old plants and fallen bolls be destroyed by burning them. Volunteer plants during off season and alternate hosts, like the cotton tree, and other perennial varieties of cotton, especially those that are found near cotton fields, should be destroyed to prevent the insect from breeding there prior to the regular crop.

As most of the aestivating larvae are found in the fastened seeds, it is suggested that all seeds for planting be fumigated or dried well before storing them in tightly closed containers.

The suggestion of Fletcher (1917) to irrigate areas, which have been under cotton, may help reduce the number of larvae that go through a period of aestivation. The idea is that when the soil is irrigated while the temperature is high, many larvae resting in the ground are induced to abandon the resting stage, to come up to the surface, then pupate and emerge as moths long before they have a place to breed in, thus breaking their life cycle.

Spotted bollworms.—In the study on the life history and habits of the two spotted bollworms during the cotton season of 1935–1936, it was observed that infestations began during the latter part of December just before the beginning of the appearance of flower buds in January. From these observations, it would appear that cutting off the attacked shoots of cotton plants and

picking and destroying all the early bolls which show signs of infestation will tend to minimize the infestations.

After harvest, it is suggested that all cotton plants, including volunteer plants should be pulled out and burned so that there will be no source of food left for the insect in the cotton fields up to the next cotton season. Since *Hibiscus esculentus* (okra) is an alternate host of *Earias fabia,* as has been previously observed by Woodworth (1921), as well as wild Malvaceous plants (Dammerman, 1929), it would be advisable to destroy those that grow near or in cotton areas to prevent the insect from breeding before the cotton season. These two measures, otherwise known as clean-up measures, have proved a success in Egypt, where they have legislation requiring that all cotton plants, after harvest be pulled out and burned together with the alternate hosts, *H. esculentus* and *H. cannabinus* (Gough, 1919). Similar measures are also employed in India.

With regard to the use of insecticides, Deshpande and Nadkarny (1936) had made extensive tests with lead arsenate, Paris green, calcium arsenate and sodium silico-fluoride. When used as dust they have great possibilities of being useful in controlling the spotted bollworms. However, they observed, as did Folsom and Bondy (1930) with the use of calcium arsenate, that the use of both insecticides (calcium arsenate and sodium silico-fluoride) was followed by heavy infestations of the cotton aphid (*Aphis gossypii* Glover).

TESTS WITH DERRIS ON *EARIAS FABIA*

On March 2, 1936, 5 caterpillars of *Earias fabia* were dusted in the laboratory with a fifty-fifty mixture (by weight) of derris dust and "gaogao." The derris dust had a rotenone content of about 3 per cent. An hour after dusting, the caterpillars were observed paralyzed and all died in a day.

On March 24, 1936, the test was repeated on 10 caterpillars. It was also observed that the larvae were paralyzed an hour after dusting, and on the second day all were dead.

In connection with these tests, it may be of interest to include the following observations made in connection with a dusting that was made with derris-gaogao on cotton plants in one of the plots at the Philippine Carnival Exposition in 1936. The main purpose of dusting was to control the leaf-eating caterpillars, especially those of *Anomis* (*Cosmophila*) *erosa,* which were found abundant on cotton plants. The dusting was performed at about 9 o'clock in the morning. Between 2 and 3 o'clock in the afternoon the plants were examined and collec-

tion was made of the insects found, especially those affected by the treatment. The insects collected were the following: 96 caterpillars of *Anomis* (*Cosmophila*) *erosa*, all paralyzed and 61 of them died after 2 days; 5 caterpillars of *Earias fabia*, all paralyzed and all died after 2 days; 19 adults of the local cotton boll weevil, *Amorphoidea lata*, all dead and were collected from inside the corolla of the flowers; 4 adults of the cotton stainer, *Dysdercus megalopygus*, all dead; 9 ladybird beetles (predators), all dead; 4 hymenopterous insects, all dead and were collected from inside the corolla of the flowers; 16 larvae of *Prodenia litura*, all vigorous and none died.

The results of the tests in the Entomology Laboratory, Manila, and in the open with derris-gaogao indicate that the mixture bids fair to be an effective remedy not only for the larvae of *E. fabia*, but also for other insect enemies of cotton. Further tests are necessary with the object of finding out, among other things, the rate and cost of application per hectare.

NATURAL ENEMIES

The pupa of *E. fabia* and that of the pink bollworm were found to be attacked by a hymenopterous parasite belonging to the genus *Brachymeria*. The introduced egg parasite, *Trichogramma minutum*, was observed to readily parasitize the eggs of the two spotted bollworms in test tubes. Tests conducted showed that 30 females of *T. minutum* could parasitize about 500 eggs of *Earias fabia*. The efficacy of using *T. minutum*, however, in the field remains yet to be studied.

THE COTTON STEM WEEVILS

(*Pempheres affinis* Faust.)

Injury and habits.—The cotton plants are attacked by this pest even before they are in bloom (plate 5, fig. 1). The female adult lays eggs on the stem and upon hatching, the larva mines within the stem (plate 5, fig. 2) of the plant and causes the appearance of swellings or gall-like formations on the affected parts. The infested plants become stunted and may succumb if the injury is severe. The infested plants easily break down when there is a strong wind. Pupation takes place in a chamber within the stem prepared by the larva.

Observations on beetles confined in vials showed that the male adult was much more active than the female. It was also observed that mating took place several times during the day, particularly in the morning. Sometimes the male was on the female for even longer than five minutes.

Life history.—So far, there are no local data on the life history of the pest. However, in a paper on *Pempheres affinis* in the Madras Year Book, Madras Department of Agriculture for the year 1918, as referred to by Ballard (1922), the following are given as the average periods for the different stages in the life history of the insect:

Egg stage	10 days
Larval stage	35 days
Pupal stage	12 days
Adult	30 days

Descriptions.—The adult insect is about 3 millimeters long, and is dark gray. The male, as was observed by Ballard (1922), could be distinguished from the female by the presence of a spine above the coxal cavity of the foreleg. In the corresponding part of the female, only a tubercle is present.

A full-grown larva is wrinkled, yellowish brown, crescent shaped, legless and the mandibles are dark brown. It measures about 7 millimeters long and 1.5 millimeters wide.

The pupa is naked, yellowish and resembles the adults as to form and is about 3 millimeters long.

Control.—Prompt cutting off of the infested stems and burning them is suggested. If the attack is too advanced, the whole plant should be pulled out and burned to kill the larvae or pupae inside. Early collection of the adults is also recommended as it is possible to see them crawling on the stems during the day, especially in the morning.

THE LEAF-EATING CATERPILLARS

The Cotton Semi-Looper or "Abutilon Moth" (*Anomis erosa* Hubn.)

Injury and habits.—This green and semi-looper (plate 6, fig. 1) or measuring caterpillar has been found quite common on cotton as a leaf feeder (plate 6, fig. 3). Judging from its work, it is capable of causing great injury when present in abundance. The adult female moth lays her eggs singly on the lower surface of the leaves. Upon hatching, the tiny caterpillars feed on the lower surface of the leaves, leaving only the upper membrane or epidermis. After the first molt, however, the caterpillars consume the whole tissue. The full-grown larva when ready to pupate incloses itelf by folding a leaf at one side with its silk or thread.

This insect is also found in the United States where it is known as the "abutilon moth." There, the abutilon plant was found by Chittenden (1913) to be the insect's preferred host. This species is widely distributed in Asia.

Besides on cotton, the caterpillars have been observed to feed locally on the leaves of cowpeas. In Woodworth's host index (1921), okra is included as one of its hosts.

Life history.—The following records of the life history of the insect were obtained in the Entomology Laboratory at Singalong, Manila:

Egg stage or incubation period	2 to 3 days
Larval stage	2 to 16 days
Pupal stage	6 to 7 days

DESCRIPTION

The egg (plate 9, fig. 2).—The egg is somewhat circular in shape, about 0.6 millimeter in diameter, flattened, with ridges radiating from the center. They vary in color, from light green to bluish green, and can be seen with the naked eye after one has learned to recognize them on the leaves.

The larva or caterpillar.—The caterpillars molt four times, that is, there are five instars. When newly hatched the caterpillars are about a millimeter long and are pale yellow but they soon become light green after feeding and the color becomes more pronounced as they grow older. White parallel lines or markings run practically the whole length of their bodies. The full-grown caterpillar is about 4 centimeters long and 3.5 millimeters wide.

The pupa.—The pupa is dark brown measuring from 15 to 17 millimeters long and from 4 to 4.5 millimeters in diameter. At the end of the last segment are four spines, two of which are curved downward or ventrad. There are also four bristles which are distinctly longer than the spines and which are curved or rolled at the end (all of these are parts of the cremaster).

The adult.—The adult female is brownish yellow, about 1.2 centimeters long and has a wing expanse of about 3.8 centimeters. The male is of about the same size. The outer or front wings are with transverse, dark brown wavy lines, the apical or posterior half being darker and more so in the case of the male. There is a small faint white spot or mark near the front margin of each outer wing about one-third the distance from the base.

Control.—The cotton field should be gone over often and the caterpillars and pupa should be picked and crushed as both stages could be easily recognized. Dusting or spraying with either lead or calcium arsenate (preferably with the latter, as it is cheaper) may also be employed.

For dusting, calcium arsenate may be used alone or mixed with "gaogao" or ordinary inert lime in the proportion of 1 part of calcium arsenate to 5 to 10 parts by volume of the filler or carrier. Dusting can best be done early in the morning when there is dew and when there is no strong breeze.

For spraying, use from 1.5 to 4 grams of calcium arsenate per liter of water or 7 to 14 spoonfuls (levelful) for every petroleum canful (about 5 gallons) of water. Then stir thoroughly before, and occasionally, while spraying, to keep the calcium arsenate particles in uniform suspension. A bucket pump, provided with several meters of rubber hose and with a good nozzle that will deliver the spray in a fine mist, may be used.

Spraying with soap solution at the rate of 10 to 20 grams per liter of water (1/5 to 2/5 kilo per 5 gallons or one petroleum canful of water) has also been found effective, especially on the young caterpillars.

Derris-"gaogao" dust, mentioned in the control of the spotted bollworms, may be used for the same purpose.

Natural enemies.—A hymenopterous parasite (*Euplectrus manilae* Ashmead) has been found to attack the caterpillars. This tiny insect (see plate 6, fig. 1; also plate 10, figs. 1 to 4, inclusive) which is about a millimeter long, with the head and thorax black and the abdomen and legs and antennae pale yellow, lays its eggs on the back or sides of the caterpillars and the larvae feed on the hosts by sucking their juices. When full grown, they move to the underside of the dead hosts (which are almost all skin and fastened to the leaves with silken threads) and then pupate. This parasite is certainly of help in keeping the pest in check.

The egg parasite, *Trichogramma minutum* Riley (plate 8, fig. 6) introduced by Doctor Merino from the United States in March, 1934, has been found to attack the eggs of *Anomis* (*Cosmophila*) *erosa* in the laboratory, and liberations have been made in various places.

THE COTTON PYRALID LEAF ROLLER

(*Sylepta derogata* Fabr.)

Injury and habits.—Another caterpillar which has been found rather common on cotton is that of a pyralid moth, *Sylepta derogata* (plate 6, fig. 2). This is known to be a serious pest in India. The insect lays its eggs singly on the underside of the leaves like *Anomis erosa*. The first instar caterpillar feeds on

the lower surface of the leaves leaving the upper membrane intact. After the first molt the caterpillar begins to consume the whole tissue and to roll the leaves to enclose itself with its silky threadlike secretion. It then pupates. This habit of rolling itself makes the pest more difficult to control than *Anomis*.

Life history.—The life history of the pest as worked out in the Entomology Laboratory at Singalong, Manila, is as follows:

Egg stage	2 to 3 days
Larval stage	14 to 16 days
Pupal stage	6 to 7 days

Descriptions.—The following are the descriptions of the different stages:

The eggs (plate 9, fig. 3).—The eggs are elliptical, about 0.6 millimeter in diameter and are laid singly, as stated previously, on the lower surface of the leaves. They are pale yellow in color and are difficult to detect on the leaves without the aid of a lens.

The larva or caterpillar.—The caterpillar molts five times, that is, there are six instars. The newly hatched larva is about 2.6 millimeters long, transparent and pale green with a pale brown head. In the subsequent instars, the larva's head is brown. The dorsal portion of the prothorax is heavily chitinized and this chitinized area is brown like the head. The full-grown larva is about 2.2 centimeters long and about 3 millimeters in diameter.

The pupa.—The pupa is from 1 to 1.3 centimeters long and from 2.5 to 3 millimeters at its greatest width. It is brown, turning darker when the adult is about to emerge. At the posterior or anal end are eight stout bristles, like those of *Anomis*, which are also rolled or curved at the end.

The adult.—The adult is yellowish-white measuring from 2 to 2.3 centimeters across the wings. On both fore and hind wings are numerous brown transverse wavy lines. The male is slightly smaller than the female and has its posterior abdomen more pointed and somewhat longer than that of the female.

Control.—(1) Spraying with calcium arsenate as suggested for *Anomis erosa*. (2) Collecting the caterpillars. (3) Spraying with soap solution of the same strength as that for *Anomis* may also be practiced.

TORTRICID LEAF ROLLER

(*Homona phanaea* Meyrick)

Injury and habits.—Another common caterpillar, which has been found on cotton is the larva of a tortricid moth, *Homona*

phanaea (plate 6, fig. 4). The insect lays its eggs in masses on the upper surface of the leaves of the host plant and the eggs are arranged like scales. Like the larva of *Anomis* and *Sylepta*, the newly hatched caterpillar feeds on the under surface of the leaf, leaving the upper membrane. In the succeeding instars, however, the larva begins to roll the leaf and consume the whole tissue. Within this too, pupation takes place.

Life history.—The following is a record of the life history of the insect in the Entomology Laboratory at Singalong, Manila:

Egg stage or incubation period	5 days
Larval stage	17 to 18 days
Pupal stage	5 to 7 days

Descriptions.—The different stages in the life history of the insect are as follows:

The eggs (plate 9, fig. 4).—The eggs are small, flat, and elliptical, and are laid one overlapping the other. The entire egg mass, which may contain from 99 to 250 eggs, is flat, elongated and is very smooth and glossy. The eggs are yellowish along the periphery, while towards the center, they are translucent.

The larva or caterpillar.—The larva molts five times before attaining full size. The newly hatched larva is pale yellow with the head and thorax dark in color. As the larva grows the dark color of the head and of the dorsal portion of the prothorax turns shiny black. A full-grown larva measures 2.5 centimeters long and 0.3 centimeter wide.

The pupa.—The pupa is 7 to 10 millimeters long and from 2 to 3.5 millimeters wide. It is reddish brown. The dorsal surface of the abdominal segments has minute spines arranged across the segments in two rows, the anterior row being more developed than the posterior. The cremaster is also provided with bristles, but these are distinctly shorter than those of the pupae of *Anomis* and *Sylepta*. The bristles are likewise curved or rolled at the end.

The adult.—The adults are brownish-yellow. The male is much smaller than the female, being only about 8 millimeters long while the female is 12 millimeters. The male has a prominent "costal fold" of scales at the base of the front or costal margin of the fore wing. The wing patterns in both sexes are similar.

Control.—Essentially the same control measures given for *Sylepta* are suggested. Collecting the egg clusters is also suggested.

Hymenopterous parasites have also been reared from the larvae of *Sylepta* and *Homona* treated in this paper. These are of help in the control of the pest.

Liberations of *Trichogramma minutum* have been made in the field and the parasite has been reared from egg clusters of *Homona phanaea*, indicating that this introduced parasite shows promise of getting established here.

OTHER CATERPILLARS OBSERVED TO ATTACK COTTON BOLLS AND LEAVES

Heliothis armigera Hubn.—This pest is comomnly known as the corn ear worm, a cosmopolitan insect, which was found to attack cotton bolls, but the infestation at Singalong was found very negligible. Baltazar (1934) states, however, that the caterpillars are a serious pest in the Ilocos Provinces, feeding not only on the bolls but also on the flowers and squares.

Cotton leaf miner (*Lithocolletis triarcha* Meyrick, plate 9, fig. 8 and plate 11, fig. 1).—This has been found rather abundant in Singalong, Manila. As the name suggests, the flattened larvae feed inside the leaves causing blotches or mines which later dry up. Two parasites of this leaf miner have been identified as *Elasmus* sp., near *homonae* Fen., and *Sympiesis* sp. by Mr. Gahan of the U. S. Bureau of Entomology, which identifications were sent to us by Mr. Cushman of the same institution.

The collection of infested leaves and placing these in wire cages which will allow the parasites to escape and continue their beneficial work but will prevent the escape of the moths is suggested to minimize the attack.

SUCKING INSECTS AFFECTING COTTON

A number of sucking insects attack cotton, the most important being the common mealy bug (*Ferrisia virgata* Ckll.), the melon aphis (*Aphis gossypii*) and the leaf hopper (*Empoasca flavescens* Fabr.). Besides the mechanical injury done by these insects, and the loss of sap from the host plants, they also exude honeydew, which serves as a medium for the growth of sooty mold, and this interferes with the food-making function (photosynthesis) of the chlorophyll. Then there is the possibility that at least some of these sucking insects, the Oriental cotton stainer (*Dysdercus megalopygus*), for instance, and other allied species, may serve as carriers or vectors for the causal organisms or pathogens of such local diseases affecting cotton or that the punctures caused may facilitate the entrance of such pathogens. In connection with disease transmission by sucking insects of the family *Pyrrhocoridae*, the following from

H. P. Krug (1936) may be of interest (those in parenthesis ours):

> An account is given of preliminary studies of the insect transmitted internal boll disease of cotton, which in this State (S. Paulo, Brazil) is due to the following organisms, in order of importance: several species of bacteria, two members of the genus *Nematospora*, namely *N. gossypii* and *N. coryli*. Some species of yeasts, and *Penicillium* sp. were also found associated with the disease . . . . The type of infection most frequently met with is bacterial. The insects chiefly concerned in transmission are (a) various species of cotton stainers (*Dysdercus* spp.), (b) other sucking insects.

Mendes (1936) also says the following:

> In the cotton-growing regions of the state of S. Paulo, three species of "stainers" of the genus *Dysdercus* (*Pyrrhocoridae—Hem. Heter*) have been recorded attacking the bolls, and producing some damages to the fibres. The chief damage is the disease known as "Internal boll disease" or "Stigmatomycosis," transmitted by these insects.

The general effect of all these injuries, together with that of certain other associated causes, is the stunting of the plants thus producing very few or no bolls.

THE ORIENTAL COTTON STAINER

("Vacavacahan")
(*Dysdercus megalopygus* Bredd.)

Injury and habits.—The farmers are very familiar with this insect, including at least one allied species, so that both hardly need any descriptions here. The adults (plate 7, figs. 1 and 2), as well as the nymphs (plate 7, fig. 5), insert their proboscis into the different parts of the bolls and suck the juice or contents of the fruits and seeds. As a consequence of their method of feeding, they cause directly the staining of the fibers, inflicting mechanical injury to the bolls causing these to develop abnormally. They may also serve as vectors or carriers of local cotton diseases.

The female was observed in the laboratory to lay eggs in batches in the soil placed at the bottom of the battery jar used for breeding the insect (plate 7, figs. 3 and 4). The eggs are white and ovoid, each measuring about 0.8 millimeter long and 0.6 millimeter in diameter. It takes about an hour for a female to lay a batch of eggs. In the laboratory, the insects were reared on cotton and kapok seeds.

During off season for cotton, the insect subsists on the following hosts: okra (*Abelmoschus esculentus*), lumbang-bato (*Aleurites moluccana*), papaya (*Carica papaya*), kapok (*Ceiba*

pentandra), gumamela (*Hibiscus rosa-sinensis*), roselle (*H. sabdariffa*), colut-colutan (*Urena lobata*) and other related plants.

The nymphs molt four times or there are five instars. Mating was observed to take place from two to three days after the nymphs emerged into adults.

Life history.—The life history of the insect as worked out by the junior author in the Entomology Laboratory at Singalong, Manila, from March, 1937 to February, 1938, was as follows:

Incubation period	4 to 7 days
Nymphal stage	19 to 31 days
Emergence of adult to first oviposition	2 to 10 days

The life cycle of the insect from the time the eggs were laid to that when the adults began to lay eggs was from 25 to 48 days, the mean being 36.4 days.

Periods of fecundity were found to vary from 4 to 26 days with an average of about 13.0 days. A female may lay as many as six times during her lifetime. The number of eggs laid by a female at a time ranged from 41 to 84 or an average of around 69 eggs. The total number of eggs laid by a female may reach as many as 417. Adults in confinement were found to live around 23 days for the female and 29 days for the male.

THE COMMON MEALY BUG

(*Ferrisia virgata* Ckll.)

The mealy bug (plate 8, fig. 1), *Ferrisia* (*Pseudococcus*) *virgata* Ckll., is undoubtedly the most common mealy bug in the Philippines. It has been observed rather serious on cotton at Singalong, Manila, and in other places during the season. These insects are very prolific and in a relatively short time they practically cover the stems. They also attack the leaves (plate 11, fig. 2).

Superficially, it can be distinguished from other local mealy bugs by its having two prominent or conspicuous tail-like waxy fringes at the posterior or hind end of its body. Besides the powdery secretion covering especially the upper surface of its body, the insect also has numerous glossy threads or filaments with which the newly born young are concealed. The mature female is from 4 to 5.5 millimeters long. Examined under the miscroscope, the antennae are eight-segmented and the tarsal claws are without teeth or denticles.

Although this mealy bug has many enemies, three kinds of parasites having been reared, namely, *Leptomastix longipennis* Mercet, *Holanusomyia pulchripennis* Girault, and *Blepyrus insu-*

laris Ashmead, and is also preyed upon by lady beetles, among them being the common ladybird beetle, *Chilomenes sexmaculata*, and a species of *Scymnus* and aphis lions and the bug, *Geocoris tricolor*, it usually gains the upper hand during the dry season and causes considerable harm. The insect becomes full grown in about a month and begins to produce many young a few days thereafter.

Colonies of this mealy bug are attended by several species of ants, among them being the common red ground or fire ant, *Solenopsis geminata*.

THE MELON APHIDS

(*Aphis gossypii* Glov.)

The melon aphid, *Aphis gossypii* (plate 8, fig. 2), vies with the mealy bug (*Ferrisia virgata*) in destructiveness. It has been observed that it attacks the cotton plants very early and retards their growth, as the leaves are curled including the youngest ones (plate 12, fig. 1). At Singalong, Manila, two-week old cotton plants planted in October, 1934, were found badly infested by this species.

This insect is cosmopolitan and is very variable in color as well as in size. As is true with other plant lice, both winged and wingless mothers are present and both reproduce parthenogenetically, that is, without previous fertilization as is apparently true in the case of aphids in tropical and other warm climates, and of greenhouse aphids in temperate climates, as has been previously observed by Uichanco (1921 and 1924).

On bearing cotton plants that were somewhat heavily infested at Singalong, Manila, both in the field and in the greenhouse in November, 1934, most of the insects were lemon yellow in color and some were dull yellow with a greenish tinge and the adult insects were about a millimeter long and even somewhat less.

The melon aphid has also been locally observed abundant on the eggplant, melon, upo, cucumber and pechay and other cruciferous plants. Lady beetles, particularly *Chilomenes sexmaculata* (plate 10, fig. 6; see also plate 12, fig. 2), syrphid flies, aphis lions and certain hymenopterous parasites, apparently of the family Aphelinidae, have been found to prey on it. Parasitized aphids are black and thus can be easily distinguished from the live ones, which are mostly yellow in color.

Colonies of this aphid are also attended by the red ant (*Solenopsis geminata*) and other ants. Colonies of the red ant, in

particular, should be destroyed, preferably with the use of poisonous substances such as calcium cyanide and poisoned syrups, as they encourage the multiplication of the aphids.

LEAF HOPPERS

(*Empoasca flavescens* Fabr.)

The most common leaf hoppers on cotton are a small green species, *Empoasca flavescens* Fabr. (plate 8, fig. 3), measuring about 3 millimeters in length. Like the melon aphid and the common mealy bug (*Ferrisia virgata*), they become very numerous towards the end of the rainy season and cause serious harm to the cotton crop (plate 13, fig. 1). In 1926, the senior author observed that these leaf hoppers and the melon aphids and mites were chiefly responsible for the failure of an extensive cotton planting at Novaliches, Caloocan, Rizal.

The female deposits its eggs in the midribs of the cotton plants causing the injured spots to swell. Both the adults and the young are voracious feeders causing the leaves to wrinkle or curl up. They also attack eggplants and potatoes.

THRIPS

Two species have been observed on cotton causing the leaves to appear spotted or whitish. One of these (plate 8, fig. 5)—the bigger species (*Bussothrips claratibia* Moulton)—is black, about a millimeter long and the wings are black and white. The smaller one is pale yellow and is the more common in the field.

The onion thrip (*Thrips tabaci*) is also recorded on cotton but we are not certain as yet as to the identity of this and the pale yellow one just mentioned here.

A black bug about 4 millimeters long and which may be mistaken for an ant has been observed to prey on the thrips.

WHITE FLIES

(*Bemisia inconspicua* Quaintance)

The white fly (plate 8, fig. 4), which commonly attacks cabbage, also attacks cotton making the leaves appear sickly (plate 13, fig. 2). Under greenhouse conditions, it has been found very harmful, attacking not only cotton and cabbage, but also cauliflower, tobacco, tomato, and pechay. It has also been observed on roses and on certain other ornamental plants.

The adult insect is about a millimeter long and the body is yellow with snow white and opaque wings. The eggs are laid in groups on the lower surface of the host plants. The nymphs and pupae are preyed upon by a hymenopterous parasite and a ladybird beetle.

RED SPIDERS OR MITES

Red spiders (*Tetranychus sp.*) have been observed abundant on cotton especially during the dry season. The nature of their injury resembles that of thrips. The red spiders have also been found to attack beans and peas.

CERCOPIDS

A species of cercopid, *Machaerota ensifera* Burm., has also been observed on cotton. This feeds chiefly on the tender parts of the stems. It is not usually abundant, however, and may be considered as a minor pest. The insect is about 5 millimeters long, yellowish brown and has its scutellum reduced into a spine which is directed backward.

CONTROL MEASURES FOR THE SUCKING INSECTS ON COTTON

The cotton stainers.—As the nymphs and adults can be easily seen, they should be collected and killed either by crushing them with the fingers or placing them in a can with kerosene.

Spraying with soap solution at the rate of 15 grams of yellow powdered soap per liter of water (about 60 spoonfuls per can of water) was found effective in controlling *Dysdercus* infestation on kapok fruits in 1937 at the Singalong Experiment Station. Spraying was done with a compressed air spray pump, but a bucket pump may be employed for the purpose.

The use of derris-"gaogao," as mentioned in the control of spotted bollworms was found quite promising. The preparation should be dusted where a great number of adults is congregated.

As there are many alternate hosts, at least those near the cotton field should be destroyed.

The other sucking insects.—The cotton plants, soon after germination, are usually attacked by the mealy bugs and the aphids. The infestations are at first localized and the planter should go over the field often and examine the plants in order to control such initial infestations. Even crushing the insects with the fingers will help. They can best be destroyed, however, by spraying. The following formula for destroying aphids as well as certain other sucking insects on cotton (the thrips, white flies, the leaf hoppers) and the mites, dealt with in this paper, is suggested:

Soft yellow, laundry soap—5 to 10 grams per liter of water or approximately 1/10 to 2/10 of a kilo in one petroleum canful of water.

For the mealy bugs a stronger solution is necessary, to insure killing them. The amount of soft, yellow laundry soap should be doubled, that is, 10 to 20 grams per liter of water or ap-

proximately 1/5 to 2/5 of a kilo for every petroleum canful of water. The amount of soap may be increased if necessary.

Powdered soap, which is especially convenient for combating insects, is available in the market. It dissolves easily by vigorous stirring in a few minutes. This costs about ₱3.00 per 5-gallon can or about 12 kilos. Forty to sixty spoonfuls (levelful) for every petroleum canful of water have been found sufficient for killing plant lice, mealy bugs and other insects like thrips, white flies and their larvae. Mites are also killed by this solution.

In spraying against aphids, mealy bugs, and leaf hoppers, in particular, the spray should be directed to the under side of the leaves to be sure that the insects are thoroughly moistened with the solution.

OTHER INSECTS ON COTTON

The following insects have also been observed on cotton but were very few and may be considered of minor importance:

Sucking insects—

Dysdercus poecilus H. S.
Tectocoris lineola
Saissetia hemisphaerica
Nezara viridula
Drosicha townsendi
Ricania speculum
Dictyopara sp.

Biting insects—

Phaneroptera furcifera Stal.
Prodenia litura

The following are mentioned by Baltazar (1934) but have not been personally observed by the writers.

Sucking insects—

Helopeltis spp., said to be serious at the College of Agriculture, Los Baños, Laguna.
Antilochus nigripes (Specimens were collected by Mr. Toquero, also of the Plant Pest and Disease Control Division, from cotton in Ilocos Norte in 1931).

Biting insects—

Euproctis varians
Acontia intersepta

Dammerman (1929), in his book, entitled "The Agricultural Zoölogy of the Malay Archipelago", gives the following insects as feeding on cotton among other host plants and they are listed here for some of them, at least, occur in the Philippines:

Zeuzera coffeae Nietn.—The red coffee borer, the adult being a moth.
Collyris bonelli— a tiger beetle.
Aelopus (Epacromia) tamulus F.—a grasshopper. Recorded.
Glyphodes indica Saund.—a pyralid moth. The caterpillars attack cucurbitaceous plants in the Philippines.
Euproctes (Porthesia) scintillans Wlk.—a lymantriid caterpillar said to be a serious pest of castor plant in the Malay Peninsula.
Nisotra gemella Erichs.—a flea beetle 2.5 to 3.5 millimeters long. According to Reveche (1922), this insect feeds on okra, roselle, gumamela, colut-colutan, etc., but apparently he had not observed it on cotton.
Hypomeces squamosus F.—a weevil (Curculionidae).
Mylabris postulata Thunb.—a cantharid (Meloidae). The larvae are well known predators of locust eggs but the adults feed on the pollen of flowers, including those of cotton.
Oxycarenus lugubris Motsch.,—of the family Lygaeidae; commonly known as the black cotton bug; 3.5 to 4 millimeters long with yellowish white fore wings, the central part being brown. The insects suck the juice of the seeds. This is listed by Woodworth (1921).
Dacus ferrugineus F.—This is the mango fruit fly, the insect having been noticed in cotton bolls.
Lecanium (Saissetia) nigrum Nietn.—a scale insect.
Pinnaspis aspidistriae Sign.—a scale insect.
Pseudococcus citri Risso—a mealy bug, closely resembling *Pseudococcus lilacinus*, which is quite common in the Philippines.
Tetranychus coffeae Nietn. (*bioculatus* W. M.)—the red tea mite.

The following are also listed by Woodworth (1921) as feeding on cotton but have not been observed:

Hypolimnas masippus Linn.—a nymphalid.
Hippotion celerio Linn.—a sphinx moth.
Euxoa segetis Chiff.—a noctuid.
Oxycarenus hyalinipennis Costa—a bug (Lygaeidae).

Scale insects—

Hemichionaspis townsendi Ckll.
Pseudococcus filamentosus Ckll.
Saissetia nigra Nietn. (listed by Dammerman as *Lecanium (Saissetia) nigrum* Nietn.)
Homona menciana Walk.

In addition to these records, the following item from Espino (1920) about cotton pests reported by a Spanish investigator prior to American Occupation is of interest.

The insect enemies of cotton reported during the Spanish régime in these Islands are "grillo de los campos" (cricket), "la oruga gris de una mariposa" (*Noctua subterranea*) and "larva del *Melolontha vulgaris*."

The *Noctua subterranea* may be either one of the common noctuids, *Prodenia litura* or *Heliothis armigera* Hubn, which attack cotton, the larvae of which pupate in the soil. *Melolontha vulgaris* is a European species and is not recorded in the Philippines. It is most likely that the larva involved was that of the "toy-beetle," *Leucopholis irrorata* Chevr., the most destructive grub here which attacks the roots of many crops (Otanes, 1931) including possibly cotton. Should these and other grubs be found abundant on lands that are being prepared for cotton, they should be collected and killed. Certain other control measures, such as collecting the beetles and spraying their favorite food plants may be employed.

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ILLUSTRATIONS

Plate 1

Fig. 1. A cotton flower showing where eggs of the local cotton boll weevil (*Amorphoidea lata*) are laid.

2. A fallen square due to the work of the grubs or caterpillars.
3. A grub, very much enlarged.
4. A pupa, very much enlarged.
5. An adult, very much enlarged.

Plate 2

Fig. 1. Adult of *Pectinophora gossypiella*, enlarged.

2. Eggs, very much enlarged.
3. Larva, back and side views, enlarged.
4. Pupa, enlarged.
5. Adult of *Earias fabia*, enlarged.
6. Larva of *E. fabia*, back and side views, enlarged.
7. Cocoons of *E. fabia*, enlarged.
8. Eggs of *E. fabia*, enlarged.
9. Adult of *E. chromataria*, enlarged.
10. Larva of *E. chromataria*, back and side views.

Plate 3

Fig. 1. Fastened seeds of cotton showing where larvae of *P. gossypiella* rest or aestivate. These seeds passed through the cotton gin with the larvae in them uncrushed. Lower photo shows the same seeds separated.

2. At left is an abnormally matured cotton boll due to the attack of the pink bollworm. At right, a normal boll.
3. Cotton bolls attacked by the pink bollworm.

Plate 4

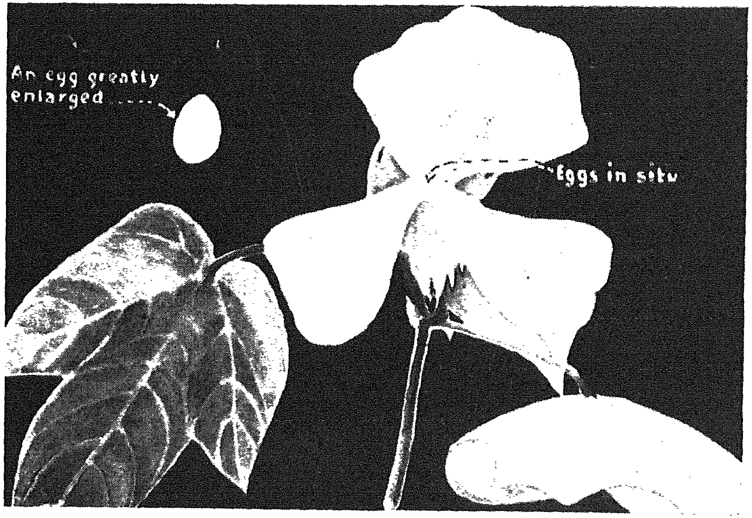
Fig. 1. Portions of cotton shoots cut before the blooming stage showing injury by the larvae of *E. fabia*. A caterpillar is shown by an arrow.

2. Cotton plants with their shoots damaged by the larvae of *E. fabia*.
3. Cotton bolls and a flower bud showing the larvae and the exit holes of the adults of *E. fabia*.

Plate 5

Fig. 1. The cotton stem weevil (*Pempheres affinis* Faust.).

2. Portions of cotton stems showing injury by larvae of the cotton stem weevil.



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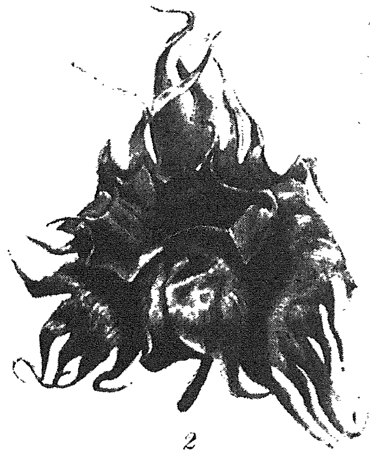

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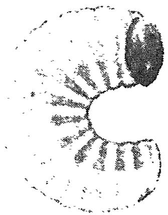

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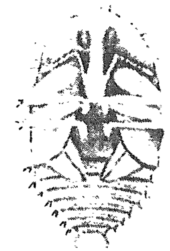

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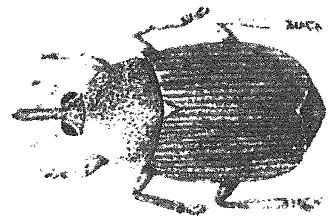

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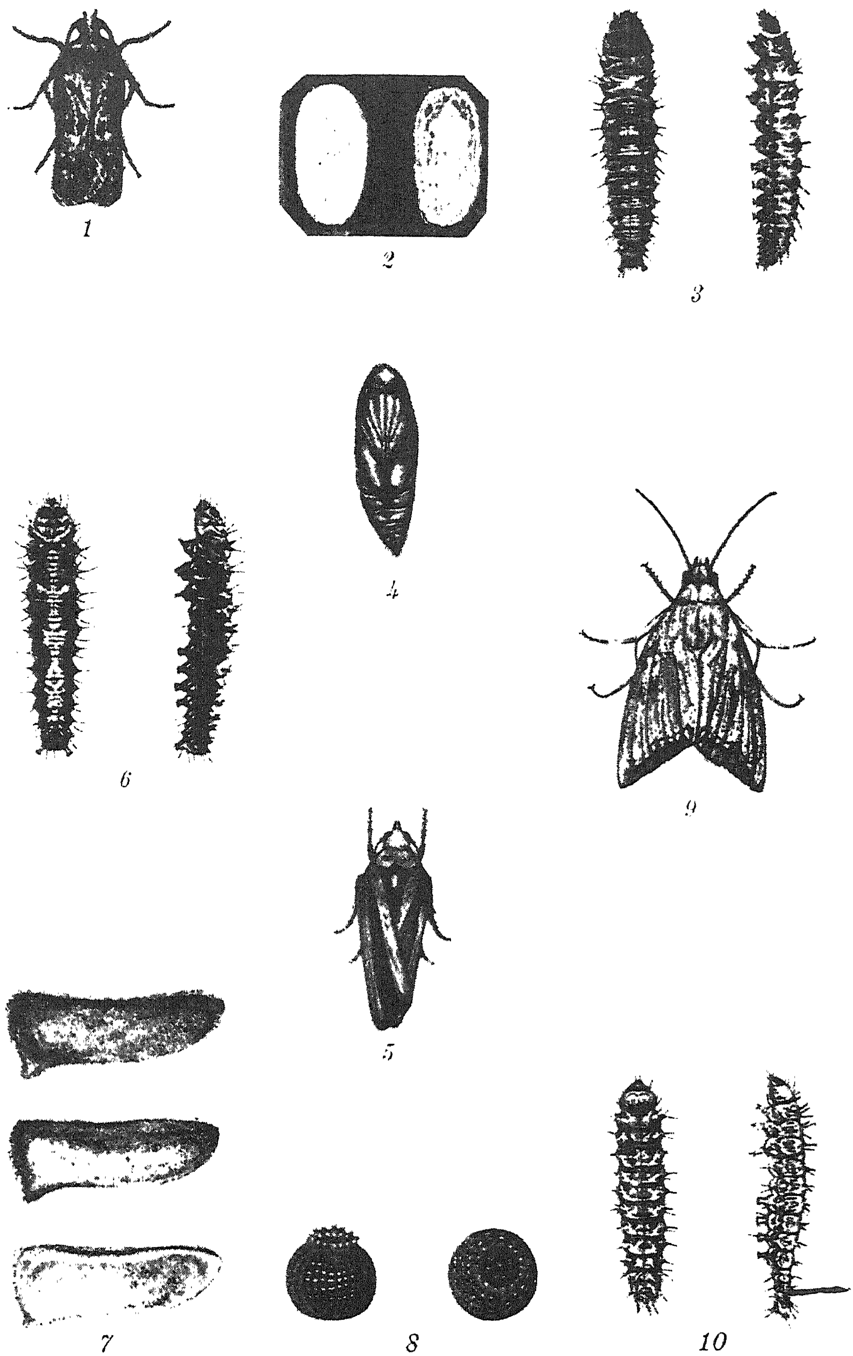

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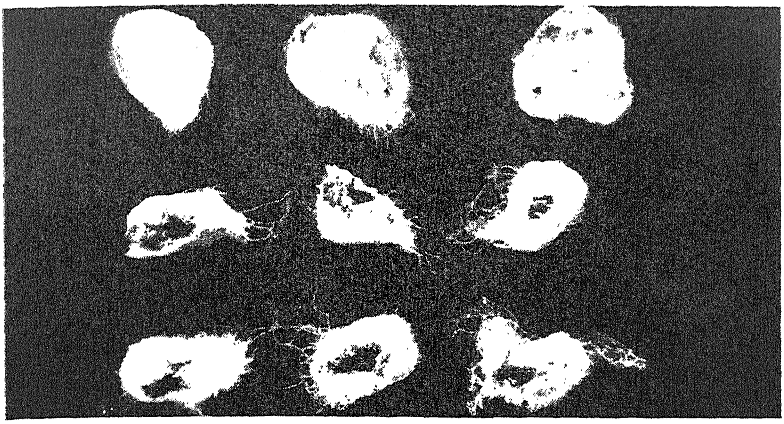

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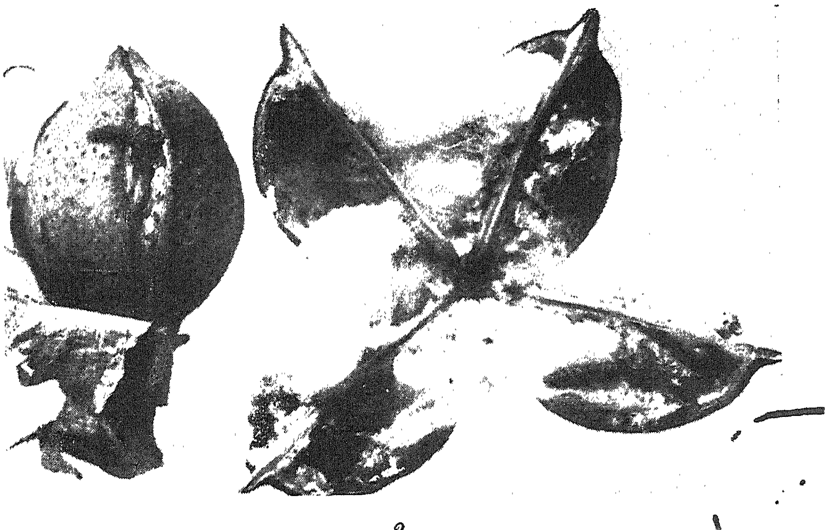

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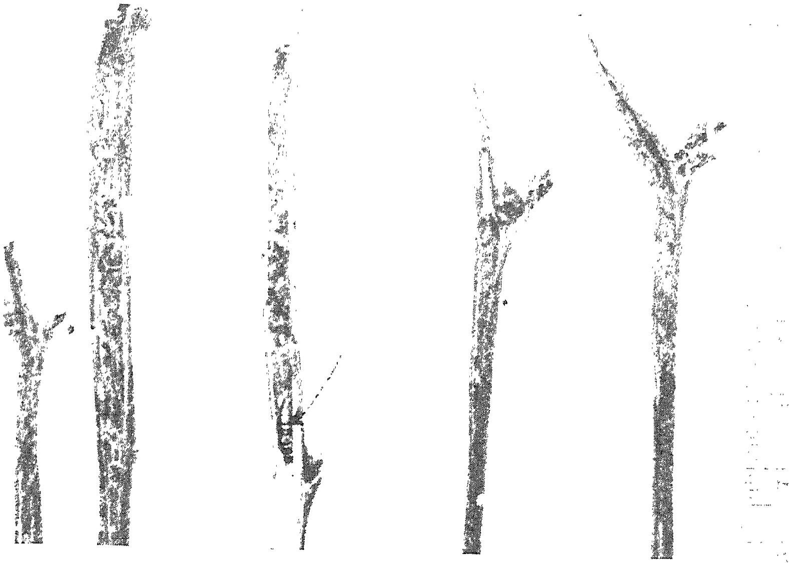

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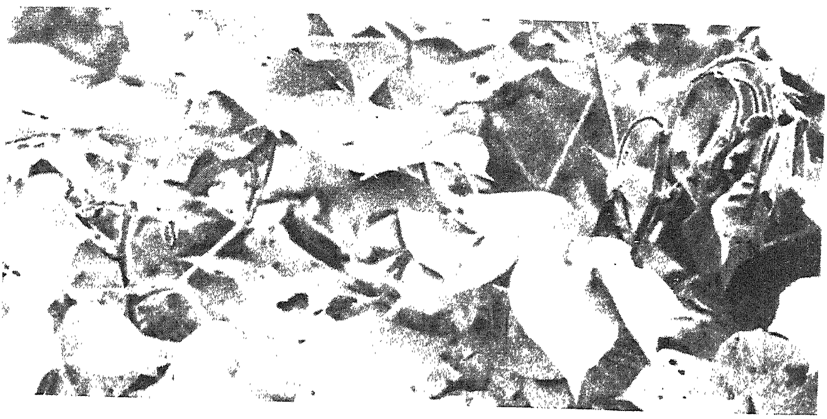

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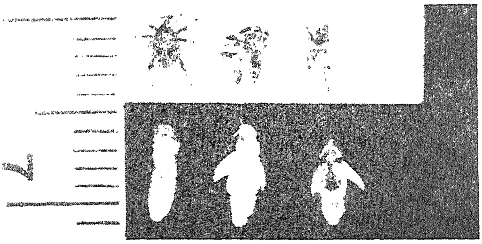

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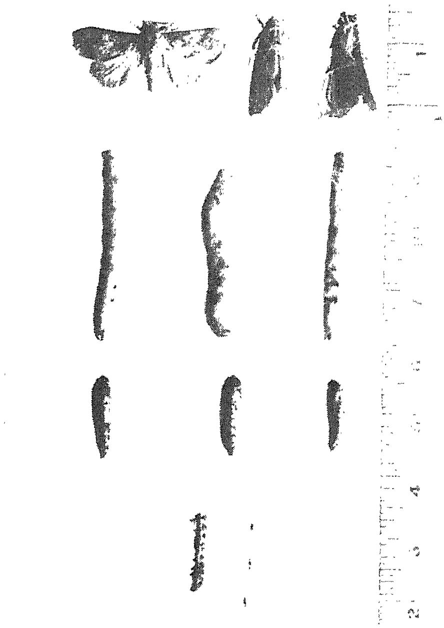

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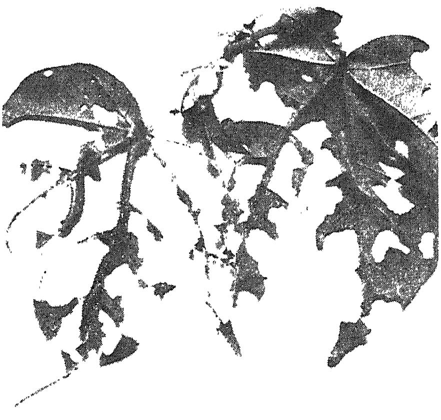

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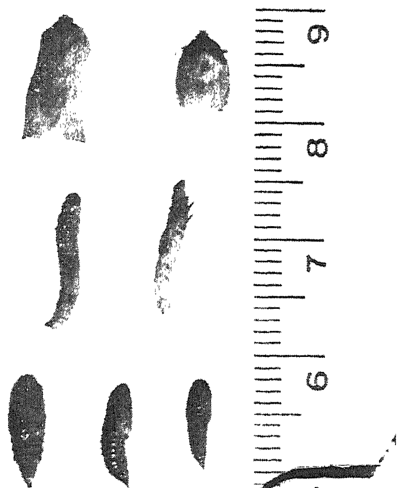

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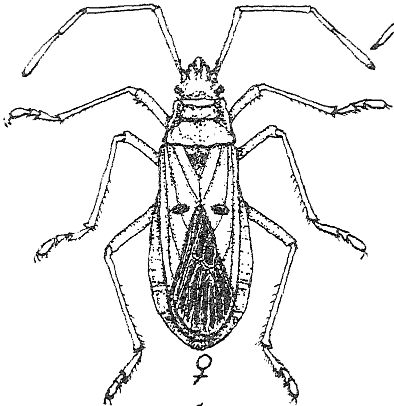

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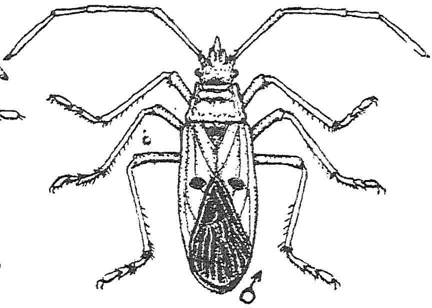

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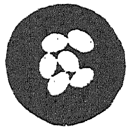

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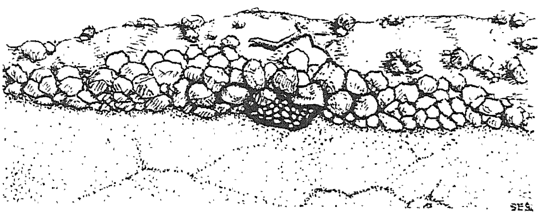

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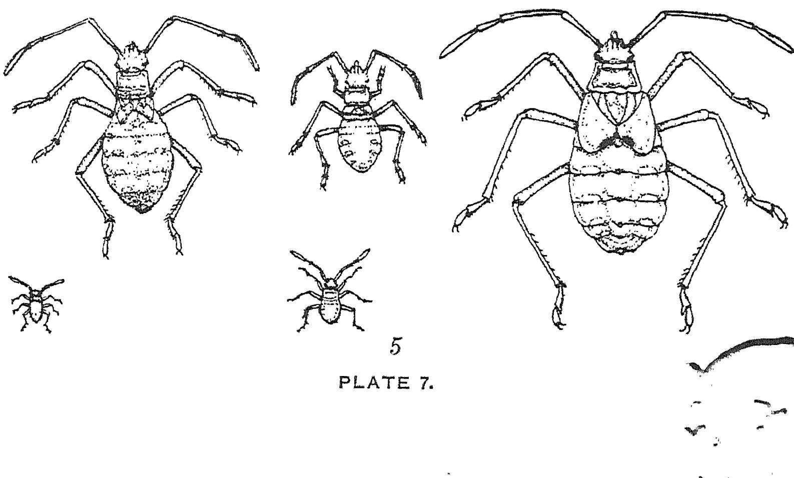

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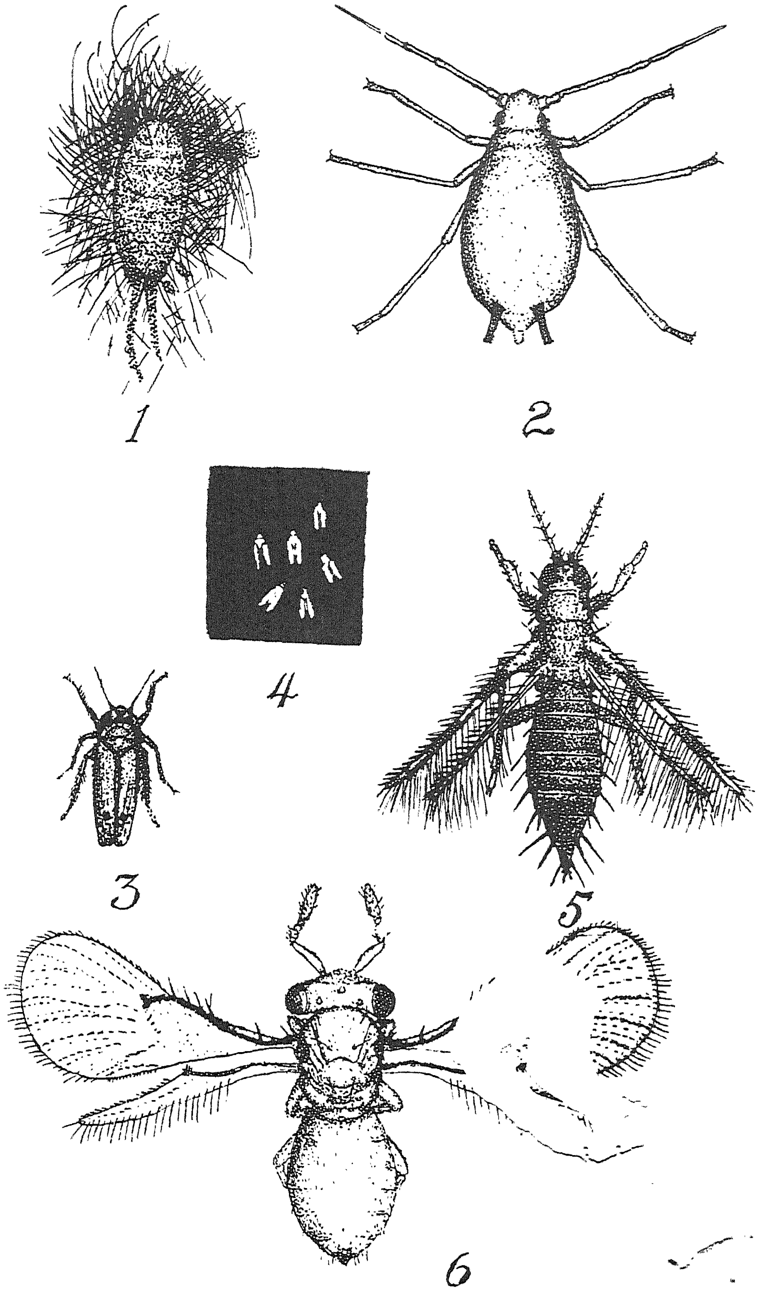

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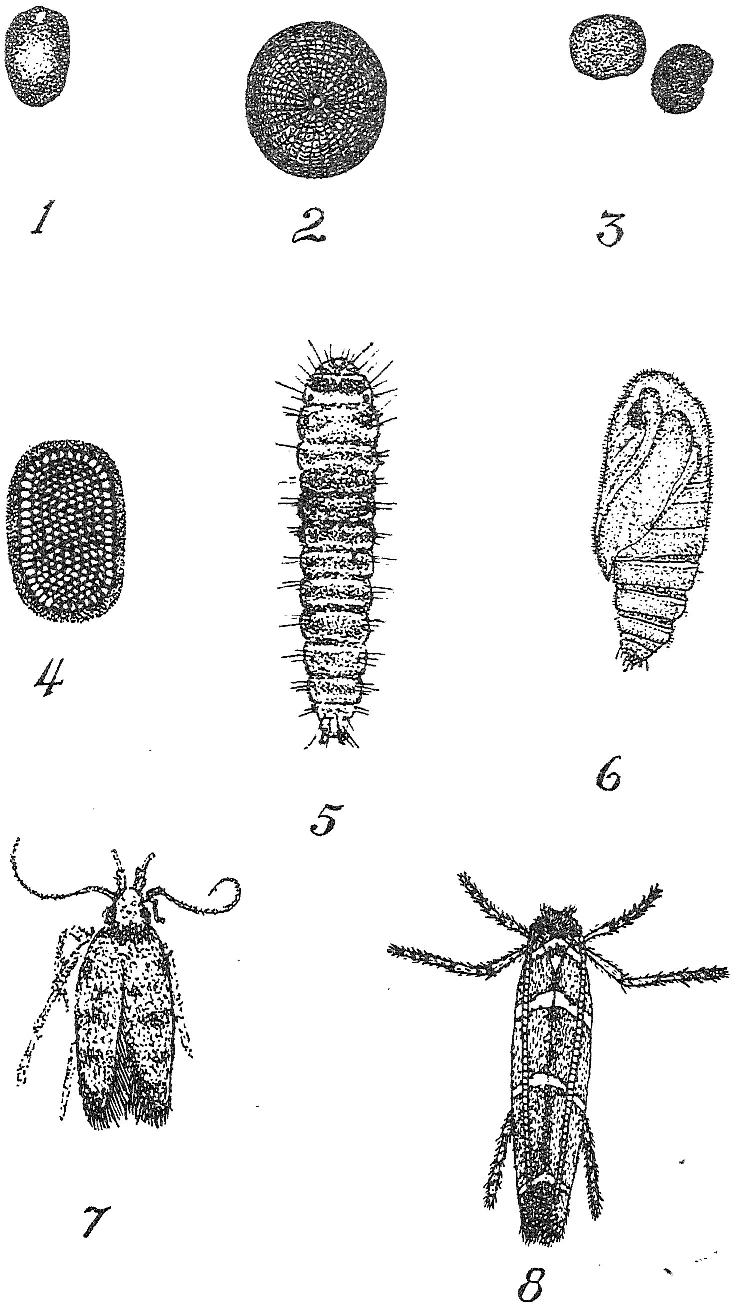

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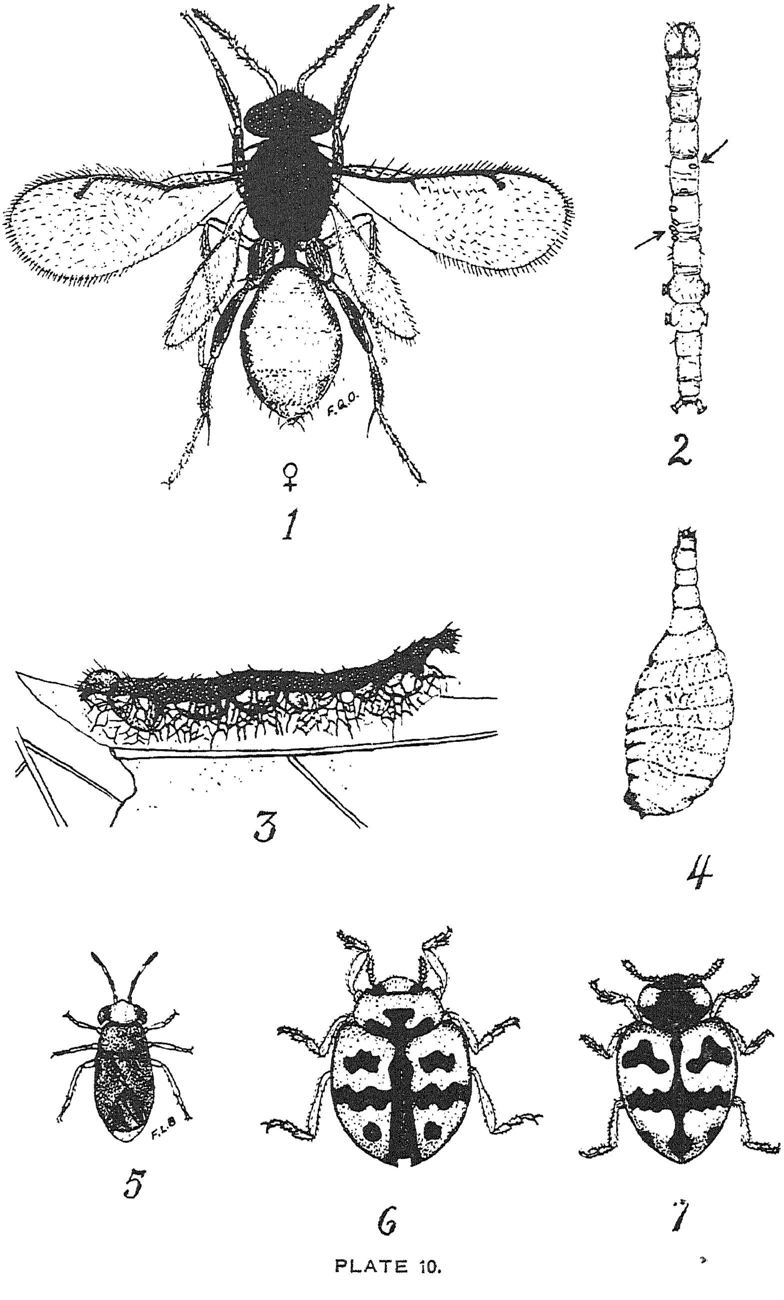

PLATE 10.

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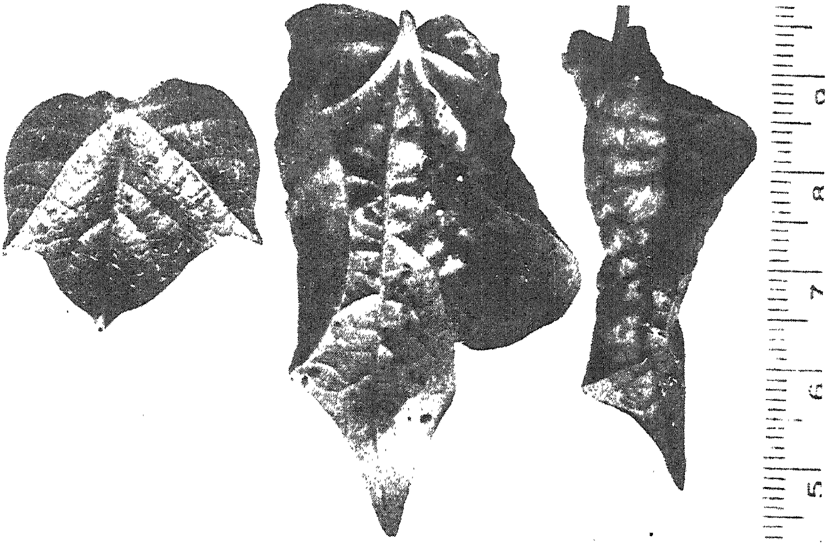
PLATE 11.



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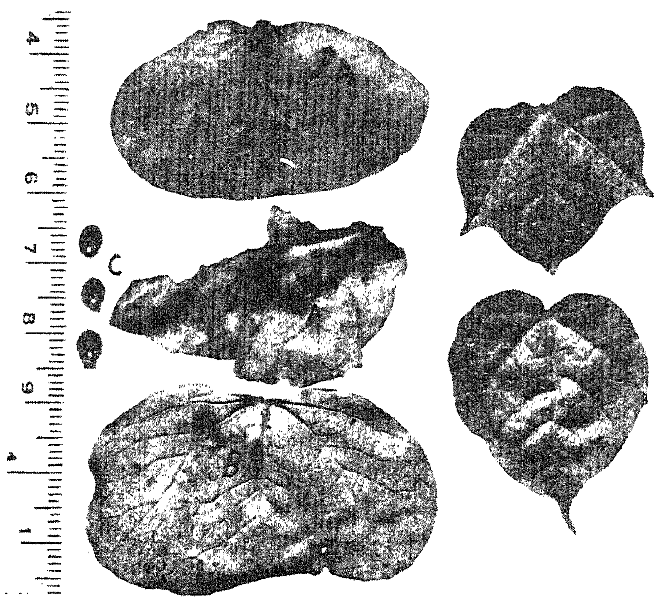

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PLATE 12.

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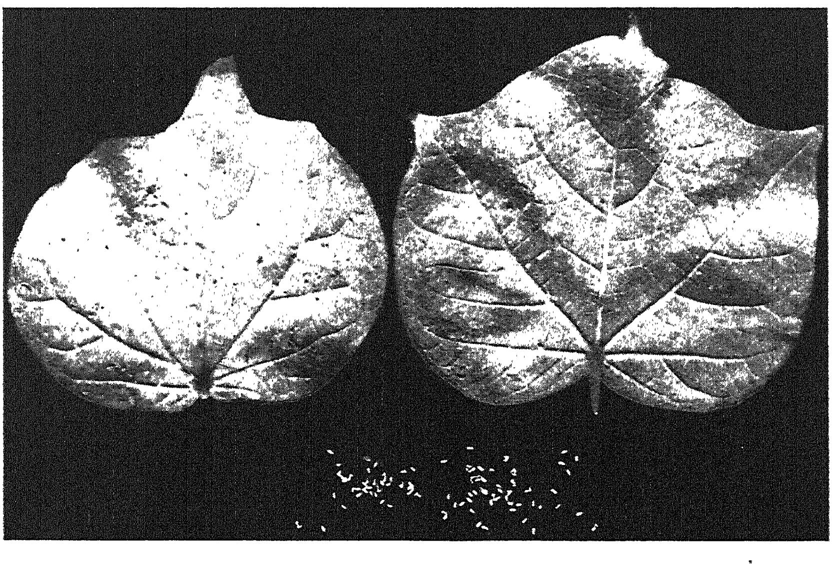

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PLATE 13.

THE BACTERIAL WILT OF THE ABACÁ (MANILA HEMP) PLANT IN DAVAO: I. NATURE OF THE DISEASE AND PATHOGENICITY TESTS [1]

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Of the Bureau of Plant Industry

FIFTEEN PLATES

An abacá disease, which was recently reported as "abacá wilt"(5), "vascular disease"(1) and "banana-wilt-like disease" (2) is now considered to be the most serious of all the abacá maladies found in Davao, Mindanao. Other abacá diseases of major economic importance in Davao are the bunchy-top, the most notorious abacá ailment which holds an evil record of having reduced to almost extinction the once-flourishing abacá industry in the provinces of Cavite, Laguna, Mindoro, and Batangas, and the mosaic whose rapid spread has somehow affected the industry. A severe outbreak of any of these major diseases in a plantation means a direct financial loss to the planter since it entails a total destruction of the plantation. But among these major troubles of abacá, the wilt disease has recently caused much alarm in Davao owing perhaps to its extreme destructiveness. Ocfemia(2) (5) attributes the disease to *Fusarium oxysporum* Schlt. f. 3 Wr. = *Fusarium cubense* E. F. S., a prolific fungus well known to be the cause of a widespread banana disease known as Panama disease or banana wilt(6), while Calinisan(1) observes the association of both bacteria and *Fusarium* with the abacá plants affected by the disease. The findings of these two investigators have also called attention to the probable complex nature of the abacá wilt in Davao and have hinted on the difficulties which may be encountered in investigating this disease. Ocfemia(2) (3) (4), for instance, observes that the disease is complicated by the attack of a stem weevil (*Odoiporus paganus* Uichanco) while Calinisan(1) seems to insinuate that it may not be improbable that vascular wilt disease of both bacterial and fungal origin may occur in the same plantation or in the same plant at the same time.

Owing to the rapid spread of this disease which has caused no little alarm in Davao City in 1937, and in view of the vague-

[1] Read at the Fifth Philippine Science Convention held on February 22, 1939.

ness and inadequateness of present knowledge about its real nature and its causal relations, Dr. F. M. Clara, chief, Plant Pathology Section, Bureau of Plant Industry, suggested a renewal of the investigation on this disease assigning the senior author to undertake the work. In the present paper the disease is called "bacterial wilt of abacá" since the results of the present investigation show that it is due principally to a species of bacteria as will be discussed partly in this report and in succeeding reports.

OCCURRENCE

The first published report on the occurrence of the wilt disease of abacá in Davao was made in 1937 by Ocfemia,(2) (3) (4) who observed the similarity of the disease to the banana wilt caused by the fungus *Fusarium oxysporum*. The surrounding circumstances in which the disease commenced its depredations are now impossible to trace with certainty. However, there seems to be a close agreement in the information given by some abacá planters that the disease was first noticed in 1931 at Upper Bayabas, Guianga District, 3,000 to 3,600 feet above sea level. Whether this place served as the focus of infection for all of the places that were discovered later, nobody could tell. The probability is, that there were several foci of infection which might account for the sporadic occurrence and almost simultaneous discovery of the disease in several other places. Perhaps the disease might have been present in those places for some length of time before it was actually discovered, but since it was localized in certain parts of the field and the damage that it caused was at first rather insignificant, abacá growers failed to notice its presence. In a survey of abacá diseases conducted under the direction of the junior author in places within the limits of Davao City in 1937, the disease was found serious in certain abacá fields in Barakayo, Tongkalan, Gumati, Lipadas, Upper Bayabas, Serib, Manambulan, Catigan, and Cabantian and slight in Mintal. In 1938, the same disease was also found occurring in the Municipal Districts of Saug, Pantukan, Kapalong, and Malita. The prevalence of this disease was not confined within Davao Province. In October, 1938, the junior writer examined the abacá plantations in Kidapawan, Cotabato Province and noted a severe outbreak of similar disease in some of the plantations in that place.

The disease was found principally on Maguindanao abacá at both high and low elevations in Davao City. The claim that

it was present only at high elevations was not quite true. At Lipadas, a place situated near the seashore and about 10 or more feet above sea level, a field of Maguindanao abacá with an area of about half a hectare was totally destroyed by the disease. In the Municipal District of Malita several fields in lower places showed cases of wilt disease. The conspicuous scarcity of this disease at low elevations in Davao City may be attributed principally to the ability of the variety Tañgoñgon (plate 1), which is the main crop in low places, to withstand the attack of the disease. On the other hand, its greater prevalence at high elevations is believed to be due to the more extensive cultivation thereat of Maguindanao, a variety which has been observed to be highly susceptible to the disease. This variety, according to information gathered from various sources, is easily affected by drought; hence, it is not now planted on a large scale in low places where prolonged dry weather occurs occasionally. During the early part of 1931, drought, which continued for about three months, visited Davao City and destroyed about 20,000 hectares of abacá plants.[2] As it was the Maguindanao variety which was most severely affected by that drought, many planters have thought of replacing it with Tañgoñgon and then planting the former at high elevations where the climate is cool and humid. Now, the Maguindanao abacá may be seen growing elsewhere on slopes of mountains where many fields planted to this variety have been found severely affected by the wilt disease.

The bacterial wilt of abacá is usually serious in old neglected plantations [3] where the vital energy of the plants has been greatly impaired by the weedy condition of the field, and where many of these plants have been enfeebled by the attack of weevil-borers such as *Cosmopolites sordidus* Germar and *Odoiporus paganus* Uichanco. Young abacá plantations are also attacked by the wilt disease especially if they are established in wilt-infected places. Recently in January, 1939, the senior writer had occasion to observe a moderate occurrence of wilt disease on the variety Lauan-Tañgoñgon [4] in a field, which, two years ago, had Maguindanao abacá but which was eradicated, due to

[2] Published in the Bulletin of the Japanese Association in Davao, dated May 5, 1931.

[3] During any period when the price of Manila hemp is unusually low, small abacá planters are usually compelled to abandon their plantations because of the high cost of production.

[4] Lauan–Tañgoñgon is a distinct abacá strain or variety which is different from Tañgoñgon, according to Japanese planters in Davao.

the serious prevalence of the wilt disease. The reappearance of the disease in the same field might be due to the faulty disposal of infected abacá debris, despite the rigid recommendations of the Bureau of Plant Industry, and the early replanting of abacá before sufficient time has been allowed to pass to starve out the causal parasite in the soil. The disease is bound to become serious in the same field, if the plants are allowed to remain there for a much longer time.

The wilt disease of abacá spreads rapidly. From foci of infection, it spreads in many directions, but it appears that its spread is much more rapid downhill than uphill. In January, 1939, the infection by the wilt disease in Upper Bayabas and Barakayo was noted along a stretch of about a kilometer below the infected areas which were noted eleven months earlier. Since the disease is soil-borne, it is believed that its rapid spread downhill is due to the movement, during rains, of surface water which carries infected soil and infected abacá débris.

ECONOMIC IMPORTANCE

Among the abacá diseases found in Davao, the wilt disease is undoubtedly the greatest source of loss at present, but no approximate monetary loss can as yet be given. The infection by this disease in individual fields varies from slight to about 75 per cent. A severely affected field is considered a total loss to the planter, as it necessitates a total destruction of the plantation in order to prevent the rapid spread of the disease to neighboring healthy areas. In order to properly evaluate the economic significance of this disease, a systematic survey of the nature and extent of damage that it causes is necessary. In the absence of this type of survey, an idea of the destructiveness of the disease may be obtained from the results of a simple method of abacá-disease survey which the Bureau of Plant Industry instituted some time ago in Davao. The method consisted in locating the infected field and then instructing the owner to eradicate and burn all abacá plants in the diseased field, in order to destroy the source of infection, and prevent the spread of the disease. In this survey the area which was found infected by the wilt disease from May, 1937 to December, 1938 totaled 1,301.5 hectares. Since the survey covered only about one-fourth of the total area planted to abacá in Davao, it is believed that many more fields of abacá may be found infected by the disease as the survey continues. Of the infected area found in this survey, a total of 1,059 hectares have now been eradicated. The dire situation, now, has been partly

alleviated by planting Tañgoñgon, a variety which has been observed to be resistant to the disease. It is of interest to note in passing that the Tañgoñgon plants, which were recently seen growing in certain fields eradicated lately of the abacá plants affected by the wilt disease in Tongkalan, show prolific tillering and luxuriant growth, and no external signs of wilt infection (plate 2, fig. 2).

DESCRIPTION OF THE DISEASE

The abacá bacterial wilt attacks principally the varieties Maguindanao (plate 2, fig. 1), Lauan-Tañgoñgon, Balindag, and Boñgolanon. Slight variations in symptoms of the wilt disease are shown by the different varieties. The writers' study on symptoms of the wilt disease was made more detailed with the Maguindanao variety since it is the one found commonly attacked by the disease in Davao City. This study involves an external inspection of a few thousand plants in different plantations, and the felling or uprooting of about seven hundred plants which were dissected for examination of the internal symptoms and the presence of weevil-borers.

External symptoms.—One of the most important and useful external symptoms by which the disease may be readily diagnosed, and by which it is not likely to be confused with other abacá diseases in Davao, is the production of rusty-brown linear streaks on one or more or all leaves of an affected plant (plates 3 and 4). These rusty-brown linear streaks (plate 5) follow the veins, oftentimes extending throughout the whole length of the veins from the infected midrib to the margin of the lamina. The rusty-brown color spreads laterally from several points along the discolored vein toward the other veins, and blurs the clarity or sharpness of the line (plate 6). When a leaf is severely affected, the streaks appear as many parallel lines originating from the midrib (plates 5 and 6). In some cases, however, the streaks appear as broken, instead of solid lines. Yellowing of the tissues along the veins soon follows the development of the linear streaks. Where the streaks are very near each other, the yellowed areas merge together and may form stripes of yellow coloration (plate 7). In cases where the streaks are more or less uniformly distributed on the lamina, the entire leaf turns conspicuously yellow when viewed from a distance. During cool, wet weather the streaked leaves tend to persist in their normal position for some length of time without showing any sign of wilting. Browning and subsequent drying of the yellowed areas follow, and the leaf thereafter withers. Breaking of the tissues at the petioles or at the

midrib may take place, thereby causing the affected leaf to hang down.

There is no hard and fast rule as to which of the leaves will show first the linear-streaks symptom. In the writers' examination of several affected plants, it was revealed that they may either be the outer or central leaves. There were many cases noted in which only the outer leaves showed the linear-streaks symptom, while the central leaves did not show similar diagnostic features (plate 8). Conversely, there were also several cases in which only the central leaves showed the linear-streaks symptom (plates 3 and 4), while the outer leaves showed normal green color. Whether or not the outer leaves got the infection while they were still heart-leaves has not been ascertained. Future observations will clarify this point.

In the acute case of the disease, the plant rapidly wilts, thereby giving no chance for the formation of the linear-streaks symptom on the leaves. This observation is supported by infection experiments in which wilting and subsequent death of the affected plants took place without showing the linear streaks on the leaves.

A conspicuous retardation in the rate of growth of the rolled central leaf has been observed to be another important symptom of wilt infection. There were cases in which the central leaf ceased to grow before it was totally unfurled. The plants displaying this symptom did not usually show the rusty-brown linear streaks on the leaf blade, but whether the linear streaks were present or absent, the internal symptoms in such plants always bore the characteristic features of the wilt disease. The weakened central leaf was frequently attacked by secondary rots, which usually started at its base and eventually caused its death. Certain observers claim that this type of rotting of the heart-leaf is the result of the attack of weevil-borers in the rhizome or pseudostem. While it is true that similar signs may be produced by the attack of weevil-borers or by the combined attack of these pests and the wilt disease, it is also equally true that in a wilt-infected abacá field a great many of the plants showing such features were seen without even a slight sign of weevil-borer infestation.

Narrowing of the leaves which is commonly observed on the Lauan-Tañgoñgon variety seems to be another feature of the disease. The Maguindanao abacá does not show discernibly this symptom. The narrowed leaf or leaves are frequently observed to be those that follow the streaked-leaf. The three

typical specimens of plants which show narrowing of leaves may be described as follows:

(1) With outer leaf or leaves with linear-streaks symptom, followed by one or two narrowed leaves and then by inner or central normal leaves.

(2) With outer normal leaves, followed by a leaf or leaves with linear-streaks symptom and then by a narrowed inner or central leaf.

(3) Absence of linear-streaks symptom on any of the leaves but with a narrowed inner or central leaf. (Whenever this case was found in the field an internal examination of the plant was always made to determine whether the plant was diseased or not. Every plant which fell under this case always showed typical internal infection by the wilt disease in the pseudostem and corm or corm only.)

The narrowed leaves are generally uniformly green in color, except in rare cases in which such leaves show also the linear-streaks symptom of wilt disease, or in cases in which they become chlorotic due to the mosaic disease to which Lauan-Tañgoñgon appears to be very susceptible. Older narrowed leaves have softer petioles and contain less sap than normal ones. Narrowing of the leaves is believed to be due to a disturbance in the growth of the heart-leaves, as a result of wilt infection within the plant. Whether it is a result of a direct or indirect infection of the leaf by the wilt disease, cannot be explained yet. The fact is that narrowing of the leaf blade usually takes place on leaves that follow those which show the characteristic linear streaks on the laminae.

Longitudinal splitting of the pseudostem comparable with that found on bananas affected by the Panama disease caused by *Fusarium oxysporum* (4) has not been observed on abacá plants affected by the wilt disease under study. In some cases, however, splitting of the base of the pseudostem was noted but in no case was it observed to be as prominent or as pronounced as in the Panama disease. Since such splitting may also be observed on healthy plants, it is therefore believed that it may be due to a certain injury which is of mechanical or insect origin rather than to the wilt disease. The split which is short and narrow may be deep enough to injure the bases of one or two layers of leafsheaths.

In lieu of the longitudinal splitting of the pseudostem there may be observed large blackish brown patches of rotting tissues at the base of the pseudostem. Usually this sign is found on plants severely affected by the wilt disease. In humid places the blackish brown patches may be covered by a growth of *Fusarium*, a fungus which has been found in great abundance

even on the old rotting outer sheaths of healthy plants in humid plantations.

In a diseased stool not all of the plants may show the wilt disease. While it is to be expected that older plants show the infection ahead of the younger ones, this does not always happen in many diseased stools examined, as it has been repeatedly observed that younger plants often show definite external symptoms of the disease while the older ones do not display the same symptoms. Since the usual method of infection in a stool is from "parent-to-daughter" plants the uneven distribution of the disease in a stool may be due to the uneven distribution and uneven progress of infection in the daughter plants.

Sword suckers in a diseased stool may die due to a severe infection in the bulb. The dying sword sucker first shows drying and shriveling of its small leaves. This gradually works downward to the base. Rotting follows and eventually causes the final death of the sucker.

Internal symptoms.—The internal symptoms of the wilt disease of abacá may be readily observed by cutting a transverse or longitudinal section of the rhizome and pseudostem. A diseased plant shows discolored vascular strands in the rhizome and pseudostem. Healthy tissues of the rhizome and pseudostem are clean white when freshly cut, but after a few minutes' exposure to air the cut surface turns brown due to oxidizing enzymes in the cells. In an advancing infection the color of the affected vascular strands may vary from orange buff (R)[5] to either Mars yellow (R) or sudan brown (R). In more advanced stages of infection the diseased vascular strands are more deeply stained, raw umber (R), burnt umber (R), or nearly blackish brown (R) being the usual color.

In transverse sections, the infected vascular strands in the pseudostem appear as colored dots (plate 9, fig. 1). In the early stage of the disease or when the infection is light, the discolored vascular strands may be localized in a few sheaths, which may either be the inner or more often the peripheral ones. Likewise, the infection in the rhizome may be localized in certain parts of the stele (plate 9, fig. 2). In serious infections a more or less uniform distribution of infected strands may be observed in both the rhizome and pseudostem. The daughter suckers which may grow out from the diseased por-

[5] Colors indicated in this paper if followed by (R) are those of Ridgway's Color Standards and Color Nomenclature. Washington (1912).

tion of the rhizome may get the wilt infection. The discolored vascular strands may be seen passing out from the diseased stele of the rhizome into the daughter sucker. In a diseased stool some suckers which look apparently healthy may show discolored vascular strands in the rhizome and pseudostem. The infection in those suckers can be traced back to the diseased mother plant. By cutting a series of cross sections from the rhizome to the upper part of an abacá plant seriously attacked by the disease, the infection as shown by the discoloration of the vascular strands can be seen passing out from the stele of the rhizome into the pseudostem, then into the petioles and midrib and then finally into the leaf veins.

A copious exudation of bacterial slime from the severed infected vascular strands comparable with that in bacterial wilt of bananas and plantains (6) caused by *Bacterium solanacearum* E. F. S. has not been observed in the abacá disease under study. However, if the seriously infected tissues were pressed hard, the juice that came out of the cut surface, when examined through the microscope, revealed the presence of actively motile bacteria. The plants which contracted the disease through inoculation did not also show a copious exudation of bacterial slime when the affected pseudostem or rhizome was cut transversely.

In longitudinal sections, the diseased vascular strands appear as colored lines running straight from the corm to the upper portion of the plant (plate 10). By holding the thinner part of a diseased sheath before a transmitted light the discolored vascular strands can also be seen. Rotting of the parenchyma cells at certain points along the infected vascular strands is usually observed. Such rotting may involve several layers of parenchyma cells, and in a serious infection it may involve practically the entire tissues of the affected sheath. The tissues of the rhizome may undergo rotting in almost the same fashion. Patches of rotting tissues may be observed along the discolored strands, and these coalesce to form larger patches which sometimes involve the entire tissues of the stele.

The internal symptoms of the abacá wilt under study are, in many respects, similar to those described for the Panama disease in bananas. Both diseases affect the vascular bundles and cause them to become discolored. The distribution and course of infection and the arrangement of affected vascular strands are almost similar in both diseases. It is difficult to illustrate the difference between the two diseases in the color of the infected strands because this is so variable in abacá disease that

there are cases in which it cannot be sharply distinguished from that in Panama disease. The principal difference in internal infection between these two diseases may be seen in the leaf-crown. In advanced stages of abacá disease the infection can be easily traced by following the discolored vascular strands up to the highest points of the midribs of leaves and out into the laminae in the form of rusty-brown linear streaks. Where a confusing manifestation of the abacá disease occurs due to the absence of linear streaks on the laminae, or because the infection in the pseudostem has not yet reached the leaves, microscopic examination of the infected tissues should be made. Motile bacteria are found in the infected cells of the progressing infection.

ORGANISMS ASSOCIATED WITH THE DISEASE

Bacteria and fungi of the genus *Fusarium* were the organisms found commonly associated with the plants affected by the wilt disease. Weevil-borers such as *Cosmopolites sordidus* and *Odoiporus paganus* may also be found on plants affected by the wilt disease, but perhaps little importance as contributory factors of the abacá wilt can be ascribed to these insects because a majority of the wilt-infected plants examined did not show them. However, their attack weakens the plants and predisposes these to infection, and the injuries that they cause may serve as avenues for the entrance of the parasites into the tissues. Also, the possibility of their being carriers of the disease should not be ignored.

Under the microscope an abundance of actively motile bacteria will always be seen in sections across the rusty-brown linear streaks on the leaves and the discolored vascular strands in the petioles, midribs, and leafsheaths. These linear streaks have already been discussed here as one of the most useful diagnostic symptoms of the disease. Motile bacteria are also found abundantly in the discolored vascular strands in an advancing infection. Cells which are filled with motile bacteria are, however, relatively scarce in deeply stained strands of the pseudostem and corm in advanced stages of infection, the reason for this scarcity being still unknown. Instead of the actively motile bacteria, the mycelium of *Fusarium* may occasionally be found in sections of deeply stained infected strands of the corm and lower portions of the pseudostem. In no case was the mycelium of *Fusarium* found in the affected veins of the leaves. However, the growth of *Fusarium* may be observed in the tissues of the leaves which have undergone an advanced form of rotting.

ISOLATION OF THE CAUSAL PARASITE

The organism that causes the wilt disease of abacá in Davao was isolated with much difficulty. Several attempts were made to isolate it from time to time from the affected tissues in the different parts of the diseased abacá plants, but in nearly all cases a mixture of organisms developed in isolation plates. The type of bacterial colonies that predominated in an isolation might either be scarce or absent in another isolation. Since a mixture of organisms often appeared in isolation plates, a culture of each of the types was, therefore, made and its pathogenicity was immediately tested on abacá plants which were grown from seeds or rootstocks of the susceptible variety. After several isolation and inoculation trials it was found that the pathogenic type of bacterial colony was the one that began to form in three or four days, and bore characters which were similar to those of *Bacterium solanacearum* E. F. S. It was white, wet-shining and showed a tendency to flow. The other types of bacterial colonies which were mostly fast-growing were believed to be those formed by organisms which have followed the infection caused by the primary causal parasite in abacá tissues. Owing to the vigor and more rapid growth of these secondary organisms the primary causal bacteria were often outgrown in isolation plates, hence the latter often could not develop any more. Success in isolating the causal bacteria was obtained from fresh material which showed the progressing infection. They were never isolated from tissues which showed an advanced stage of infection, because a heavy growth of secondary organisms was always obtained from such tissues. The *Fusarium* fungus which occasionally appeared in isolation plates was also cultured, and the rôle that it plays in the wilt-disease complex of abacá in Davao is also being studied.

Isolations were made from the midrib, petiole, sheath, and corm of diseased abacá plants. The material was first dipped in 1:1000 mercuric chloride solution for two minutes, and then washed with three changes of sterile water. With flame-sterilized scalpel the outer layer of tissues was removed and then the discolored inner ones were scraped off little by little. The scrapings were transferred in tubes of either nutrient bouillon or sterile water, and then pressed in the liquid. The cloudiness of the liquid indicated the presence of numerous bacteria. This was proved by microscopic examination of a small drop of the liquid. The bacteria were isolated by means of agar-poured plates.

INOCULATIONS

Materials and methods.—Only abacá plants of the Maguindanao variety were used in the pathogenicity tests. They came from seeds or rootstocks which were obtained from a healthy field in Davao, and were grown in Manila in pots, empty kerosene cans or drums containing garden soil which was previously autoclaved at fifteen pounds' pressure for two hours. The seeds which were obtained fresh from ripe fruits were first soaked in 1:1000 mercuric chloride solution and then sown in pots containing sterilized soil. The young plants which emerged from the seeds after more than twenty days were pricked into the other pots of sterilized soil when they had produced four or five leaves. Before planting the rootstocks they were first thoroughly cleaned of dead and dried tissues, and then they were dipped in 1:1000 mercuric chloride solution for ten minutes after which they were washed with several changes of water. The plants were allowed to grow for some months before they were inoculated.

Inoculations were made by either needle-pricks or hypodermic injections into the midribs of the heart-leaves, the pseudostems, corms, and roots, and by cutting off the sucker buds and smearing the cut surface with bacterial growths. The bacterial cultures used were obtained from two-to three-day-old transfers on potato-dextrose agar. In earlier inoculations the culture used came from an isolate made from freshly collected material. In later inoculations they were obtained from isolations made by passage of the bacteria through the abacá plants. The points to be inoculated were first wiped with clean cotton moistened with sterile water before any pricking or injection was done. Check plants were maintained for every method of inoculation followed.

Pricking the midrib of heart-leaf.—On June 16, 1939 five Maguindanao suckers, varying from 60 to 80 centimeters high [6] were each inoculated by needle-pricks at a certain point on the midrib of an actively growing central leaf. Signs of infection were observed on all of the inoculated leaves after five days. The infection was, however, so slow on two plants that it showed no appreciable progress when the leaves matured. These two plants produced many more leaves but none of them showed the wilt symptoms. In the other three plants the in-

[6] The height of abacá plants indicated here and elsewhere in the paper represents the height from the base of the plant to the point where the heart-leaf emerges from the crown.

fection was so rapid that it caused wilting of the inoculated leaves between the second and third weeks after inoculation. The wilted leaves broke down at the petioles and then rotting followed. The leaves that followed the inoculated ones were slow in growth, and they matured before they were wholly unfurled. These plants ceased to produce more leaves. After one and a half months, they were dug up and examined. The stele of the rhizome and affected sheaths showed discolored vascular strands. The tissues in the upper central portion of the stele showed rotting which had also partly invaded the lower tissues of the centermost sheaths. The causal bacteria were successfully reisolated from affected tissues of the stele and sheath. The needle stabs on the midribs of the heart-leaves of the check plants did not hinder their growth.

On July 7, 1939 the above experiment was repeated on two Maguindanao suckers. Positive results were obtained on one of the plants after a week. Forty-six days after inoculation the infected plant showed the linear-streaks symptoms on the leaf blade of the unfurling heart-leaf, the third that succeeded the inoculated one. On sectioning the plant longitudinally, the internal symptoms in the pseudostem and rhizome showed all the characteristic aspects of the wilt infection.

Pricking the pseudostem.—On June 13, 1939 three Maguindanao suckers, varying from 50 to 120 centimeters high, were smeared copiously near the base of the pseudostem with the bacterial growth from tube cultures on potato-dextrose agar, and then several deep pricks were made through the smear. Between 20 and 30 days after inoculation, the rolled heart-leaf of each of the inoculated plants was observed to be slow in growth and had not unfurled even after two more weeks. When, later, those rolled heart-leaves began to show signs of yellowing, the plants were dug up and examined. Discolored vascular strands, characteristic of the wilt disease, were seen in the inner sheaths and in the stele. Sections across the affected strands showed myriads of actively motile bacteria. The bacteria were successfully reisolated from one of the diseased plants. Check plants showed no symptom of the wilt disease.

On June 16, 1939 the above experiment was repeated on four Maguindanao suckers, but instead of deep pricks only shallow ones were made through the smear. None of the plants contracted the disease.

Pricking the rhizome.—On November 17, 1938 three potted abacá seedlings, ten months old from seed, were inoculated

by needle-pricks into the rhizome. No infection was noted on any of these plants even after four months.

On June 13, 1939 five suckers, varying from 40 to 120 centimeters high, were inoculated by needle punctures into the upper portion of the rhizome. Only two plants showed the infection after about a month. One of the infected plants ceased to produce more leaves because the infection which coursed through its heart-leaf had caused its sudden wilting and subsequent rotting of its tissues. The earliest indication of infection in the second affected plant was discoloration of the inner tissues of the midribs of the two innermost leaves, such discoloration being very distinct when viewed by transmitted light. Linear streaks were beginning to form at certain points on the leaf blade along the midrib of the central leaf, but they showed no further development when the affected leaf suddenly wilted a few days later (plate 11). After two more weeks general wilting of all of the leaves took place, and then the plant died. The affected plants when dissected showed typical internal symptoms of wilt disease in the innermost sheaths and stele. Sections across the diseased vascular strands showed discolored xylem vessels which were teeming with bacteria. The causal bacteria were successfully recovered from the stele, sheath, and midrib.

Injecting bacterial suspension into the midrib of the central leaf.—On October 27, 1938 nine Maguindanao seedlings, five months old were each inoculated by injecting bacterial suspension into the midrib of the unfurled central leaf. The plants were kept in a shady place near the greenhouse. Five of the inoculated seedlings contracted the disease. Between twelve and fifteen days after inoculation a few broken rusty-brown linear streaks (plate 12) began to appear on the leaf blade of the inoculated and succeeding heart-leaves of three of the infected plants. This was later followed by wilting of the streaked leaves. The other two infected plants showed signs of wilting on the inoculated leaves, but they never produced any linear-streaks symptom. General wilting of all of the infected plants (plate 13, fig. 1a) occurred between the sixteenth and twentieth day after inoculation. The diseased plants were dug up and examined. Discolored vascular strands in the midribs of affected leaves, sheaths, and rhizomes were noted. This examination also revealed that the infection which started from the inoculated points in the midrib moved downward into the stele, and from there it spread into the tissues of the succeeding leaf through its sheath. Microscopic sections across the affected vascular strands in the sheath, midrib, and linear streaks on

the leaf blade showed the presence of numerous actively motile bacteria in the xylem vessels and in the parenchyma cells in close proximity to the diseased vascular bundles. The causal bacteria were successfully reisolated from an affected sheath of one of the infected plants. The check plants which were also pricked in the midribs of heart-leaves but into which no bacteria were introduced remained healthy.

On December 3, 1938 six Maguindanao suckers, varying from 40 to 65 centimeters high, were each injected with about 1.0 to 1.5 cc. of the bacterial suspension into the midribs of vigorously growing central leaves. A week after inoculation, infection was noted on three of the inoculated plants. Since the disease affected only a few vascular strands in the midrib, as could readily be seen with the aid of transmitted light, the inoculated leaves did not show any sign of wilting. The infection which moved slowly downward was calculated to have reached the stele between the second and third weeks after inoculation. The two affected plants produced two more healthy leaves, but in each case the third ensuing leaf which appeared seven weeks after inoculation showed the characteristic rusty-brown linear-streaks symptom of wilt disease (plate 14). Sections across the streaks showed numerous bacteria in the vascular bundles. One of these plants soon succumbed. In the other plant the streaked leaf was followed by a narrowed leaf without any streaks. After three more weeks, the streaked leaf wilted. This was then followed by general wilting and later by death of the plant. A large blackish brown patch of rotting tissues (plate 15, fig. 2) was also produced at the base of this plant. The third affected plant produced two more leaves, but its last leaf ceased growing while it was partly unrolled. All of the diseased plants on dissection showed discolored vascular strands (plate 15, fig. 3) which were teeming with bacteria. The check plants which were injected with sterile water at the midribs of the central leaves showed absolutely no sign of wilt disease.

On December 6, 1938 the same method of inoculation was followed for six potted Maguindanao seedlings, 10 months old. Incipient infection was noted on two plants, but no further progress of the disease was observed even after 3 months.

Injecting bacterial suspension into the pseudostem.—Thirty-six Maguindanao seedlings, 10 months old were inoculated by injecting bacterial suspension into the pseudostem on December 6, 1938. Of this number only ten plants contracted the dis-

ease. Seven of the infected plants, some of which appear in plate 13, fig. 2, showed signs of wilting during the fourth week after inoculation. Only one plant showed the typical linear-streaks symptom before it finally succumbed. The rest of the infected plants later showed rotting of the heart-leaf. All of the infected plants, on dissection, showed the typical internal symptoms of the wilt disease in the stele and in the affected sheaths (plate 15, fig. 1a) and midribs. The wilt disease was not observed on any of the ten check plants used.

Injecting bacterial suspension into the corm.—No successful result was obtained with this method of inoculation. The tissues of the corm, being compact, would not hold the bacterial suspension. When pressure was applied to the plunger of the syringe, the liquid was forced out, hence probably not much bacteria were left in the injured tissues.

Cutting off the sucker bud and smearing the cut surface with bacterial growth.—On November 17, 1938 one of the three actively growing sucker buds of a potted Maguindanao plant, 9 months old, was cut off close to the mother plant, and then the cut surface was smeared with the bacterial growth from a 3-day old culture on potato-dextrose agar. The two innermost leaves of the mother plant wilted two weeks after inoculation. General wilting followed later and then the plant died. A month later the two other suckers, which at this time had each formed two leaves, began to show signs of rotting at the base of the youngest leaf. Rotting on these two suckers continued until they all died.

General remarks on results of inoculations.—It will be seen in the results of the above infection experiment that the inoculated abacá plants showed an irregular response to the wilt organism. Many inoculated plants did not show any sign of infection at all; others contracted the disease with rapidity; others have shown some signs of infection but ceased to show any further progress; still others showed the disease after a considerable length of time. The external manifestations of the wilt infection, as a consequence of inoculation, have also shown some variations. In some plants these were shown by wilting of either the innermost leaves or the entire foliage; in others, by the retarded or arrested growth and rotting of the heart-leaf; and still in others, by the production of linear-streaks on the leaf blade. These differences in the response of the abacá plants to inoculation with wilt organism are not clearly understood. They seem to depend partly on the indi-

vidual differences in susceptibility or resistance of the plants, partly on the succulence and tenderness of tissues, partly on the environmental factors existing during the inoculation experiment, partly on the virulence of the culture, and partly on the method and technic of inoculation.

The Maguindanao suckers used in the inoculation experiments, which were grown from rootstocks, were obtained from the different clones in a field of Maguindanao abacá in Davao. Since they did not come from a single clone they, therefore, might vary in degree of their natural susceptibility or resistance to the disease. The plants grown from seeds are supposed to be natural hybrids because the abacá flowers, according to Mr. T. G. Garrido, plant breeder of the Bureau of Plant Industry, are never self-pollinated. The pollen necessary for the fertilization of the flowers of an individual plant must always come from some foreign source, and it is very likely that the source is not only one plant but many plants, in which case the fertilized seeds in a single bunch might have not only one male parent but many male parents. This difference in parental origin might account for the difference in the degree of susceptibility or resistance to the wilt disease of the plants grown from such seeds.

It has been repeatedly observed that when inoculation was made into the mature tissues no infection resulted. A mature heart-leaf which was inoculated by needle-puncture or by injection into the midrib never produced an infection. An infection was frequently obtained when this method of inoculation was applied to the actively growing rolled heart-leaf. If the same method of inoculation is applied to the pseudostem, the point of the needle must reach the tender inner tissues in order to produce an infection. Shallow needle-pricks injured only the mature tissues of the outer leaf sheaths; hence, no infection resulted.

A greater percentage of success in inoculation was obtained during humid days. The most typical linear-streaks symptom that resulted from inoculation was produced in one that was made in the early part of the cool, showery December of 1938. This symptom was shown by the inoculated plants during the latter part of January, 1939. More rapid wilting of plants that contracted the disease by inoculation took place during hot days.

With a virulent culture, an inoculation by needle-punctures or by injection into an abacá plant could cause an infection within

a period of usually not more than two weeks. Any of the external features of the disease, such as wilting, retarded growth of the heart-leaf, and formation of linear streaks might manifest within one and a half months.

SUMMARY

1. An investigation on a serious wilt disease of abacá which has been found widespread in Davao Province and in a few places in Cotabato Province is now being undertaken. This disease caused much alarm in Davao City during the year 1937 because of the heavy destruction that it wrought on abacá in that place.

2. In an abacá-disease survey which was conducted by the Bureau of Plant Industry from May, 1937 to December, 1938, a total of 1,301.5 hectares of abacá plants in Davao was found infected by the wilt disease. Of this infected area, a total of 1,059 hectares has already been eradicated. These figures have sufficiently shown that the disease is one of major economic importance.

3. One of the most important diagnostic external symptoms of the disease is the production of rusty-brown linear streaks which follow the veins of the leaves from the infected midrib. The formation of linear streaks is followed by yellowing and subsequent wilting of the affected leaf, and death of the tissues in the yellowed areas. In acute cases of the disease, the plants rapidly wilt without showing any linear-streaks symptom. The other external features of the wilt disease which may aid in its diagnosis are retarded or arrested growth of the heart-leaf, and in certain cases, narrowing of the leaf or leaves which usually follow the streaked ones. Narrowing of the leaves is commonly observed in wilt-infected plants of the Lauan-Tañgoñgon variety. General wilting of the leaves is usually observed in serious and advanced stages of the disease. Large blackish-brown patches of rotting tissues may also be observed at the bases of the pseudostems of some affected plants.

4. An internal examination of the rhizome and pseudostem of an affected plant shows that the infection follows the vascular strands. The infection in a plant seriously affected by the disease can be traced by following the discolored vascular strands from the rhizome, through the pseudostem up to the petioles and midribs and out into the leaf veins. The internal infection shows many features similar to those described for the Panama disease of bananas.

5. Weevil-borers such as *Cosmopolites sordidus* and *Odoiporus paganus* may be found in abacá plants affected by the wilt disease, but perhaps they are not very important as causal factors of the disease because a majority of the plants examined did not show them. However, the weakening effects of their attack cause the plants to become very susceptible to wilt infection.

6. Microscopic examinations of the diseased tissues have shown an abundance of actively motile bacteria in sections across the rusty-brown linear streaks on the leaves, and also in the affected vascular strands of the rhizome, pseudostem, petiole, and midrib in the early stages of the disease. They are, however, not very abundant in deeply stained vascular strands of the rhizome and pseudostem in advanced stages of the disease, the reason for this being still unknown. The mycelium of the fungus *Fusarium* may also be found associated with the deeply stained strands of the rhizome and pseudostem but in no case has it been found in the infected veins of the leaves.

7. The causal bacterium was isolated with much difficulty because its colonies were slow-growing and oftentimes would not develop in isolation plates in the presence of other fast-growing secondary bacteria, which were believed to have invaded the abaca tissues following the primary infection. The appearance and character of the colonies were similar to those described for *Bacterium solanacearum*, the bacterium that causes a wilt disease of certain varieties of bananas and also of the solanaceous plants.

8. Inoculations of several Maguindanao abacá plants grown from seeds or rootstocks by either pricking or hypodermic injection into the midrib of an actively growing heart-leaf, pseudostem and corm have yielded some successful results. One or more of the typical external symptoms of the disease were reproduced in all of the methods of inoculation followed except in hypodermic injection into the corm. The internal infection in all plants that contracted the disease through artificial inoculation has also shown close similarity to that found in nature. Microscopic sections across the infected vascular strands and veins of the leaf showed numerous actively motile bacteria in the xylem vessels and also in the parenchyma cells in close proximity to the affected bundle. Successful reïsolations were made from some of the inoculated plants that contracted the disease.

ACKNOWLEDGMENT

The writers wish to express their indebtedness to Mr. C. Hernandez, plant quarantine officer for Davao City, and Mr. A. Evangelista, abacá-disease inspector, for valuable help rendered during the field investigation on the abacá wilt in Davao and for furnishing them from time to time with specimens.

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ILLUSTRATIONS

Plate 1

A stool of Tañgoñgon from the only plant of this variety which was accidentally planted together with Maguindanao abacá some years ago in a 6-hectare field in Gumate, Davao City. The Maguindanao abacá had been eradicated due to the serious infection of the wilt disease. The Tañgoñgon was spared because it did not show the disease. The small abacá plants that are seen in the picture are also of the Tañgoñgon variety, planted a few months after the destruction of the wilt-infected Maguindanao plants.

Plate 2

FIG. 1. A portion of a wilt-infected plantation of Maguindanao abacá in Gumate, Davao City, showing some plants killed by the disease.

2. A stand of Tañgoñgon abacá, about 18 months old in a 3-hectare field in Tongkalan, Davao City in which a serious incidence of the wilt disease on Maguindanao abacá was observed by the junior writer in the latter part of 1936. After the eradication of wilt-infected Maguindanao abacá, two successive crops of corn were grown in the same field and then during the latter part of 1937, the Tañgoñgon abacá was planted. The Tañgoñgon plants now show luxuriant growth and prolific tillering and an absence of external signs of wilt infection. Photographed March 22, 1939.

Plate 3

A sucker of Maguindanao abacá showing distinctly the linear-streaks symptoms of wilt disease at the basal part of the lamina of the unfurling central leaf. The specimen was collected in March, 1938 in Barakayo, Davao City. About X $\frac{1}{5}$.

Plate 4

A wilt-infected sucker of the Maguindanao variety showing the rusty-brown linear streaks on the rolled heart-leaf. The heart-leaf was unrolled to show clearly the linear streaks and the rotting tissues at the basal part. The specimen was collected in April, 1938 in Gumate, Davao City. About X $\frac{1}{6}$.

Plate 5

A portion of a leaf of an almost full-grown Maguindanao abacá showing the linear-streaks symptom of wilt disease. Note yellowing of tissues along and between the streaks. The specimen was collected in April, 1938 in Barakayo, Davao City. About X 1.

Plate 6

A portion of a wilt-infected leaf showing clearly the linear streaks and the spread of infection to neighboring tissues along the streaks. Note that in certain parts of the specimen the streaks appear as many parallel lines running toward the margin of the leaf from the midrib. The specimen was collected in March, 1938 at Upper Bayabas. Slightly more than X 1.

PLATE 7

Wilt disease on Maguindanao abacá. Note the yellow stripes on the unfurled part of the central leaf. The yellow stripes indicate the parts where the linear streaks may be seen. Shriveling of the tissues at the base of the third leaf may also be seen in the picture. About X $\frac{1}{5}$.

PLATE 8

A sucker of Maguindanao abacá showing the linear-streaks symptom of wilt disease on the second leaf. The central leaf does not show similar symptom. The specimen was collected in March, 1938 in Lipadas (about 10 or more feet above sea level), Davao City.

PLATE 9

FIG. 1. A transverse section of a pseudostem of Maguindanao abacá seriously attacked by the wilt disease. Note the distribution of infected vascular strands and the blackening of some of the peripheral sheaths due to secondary rots.

FIG. 2. A transverse section of the rhizome of a wilt-infected Maguindanao abacá showing distinctly the disease in a sector. (Specimens used in this plate were obtained on March 27, 1939 in Tongkalan, Davao City, from plants which showed the linear-streaks symptom of wilt disease on the leaves and an absence of the attack of both root-weevil and stem-weevil).

PLATE 10

Longitudinal sections of a Maguindanao abacá stalk collected in Tongkalan, Davao City showing the wilt-disease in the rhizome and pseudostem. The leaves of this plant showed the linear-streaks symptom of the disease and an absence of weevil-borers in the pseudostem and rhizome. Photographed March 22, 1939.

PLATE 11

Abacá plants of the Maguindanao variety inoculated by needle punctures into the rhizome. Two of the plants (pointed by arrows) contracted the disease. Note that on one of the infected plants the two wilted innermost leaves have broken down at the petioles due to loss of turgidity. The other plants did not get the infection. About X $\frac{1}{10}$.

PLATE 12

A portion of a leaf of a Maguindanao seedling, which was inoculated by hypodermic injection into the midrib of an actively growing heart-leaf, showing the linear-streaks symptom of the wilt disease on the lower portion of the leaf blade. Note that the linear streaks appear as broken lines instead of continuous lines running from the midrib to the margin of the leaf. Such formation of linear streaks was also observed in nature. Slightly more than X 1.

PLATE 13

FIG. 1. Potted Maguindanao seedlings. About X $\frac{1}{9}$.

a. Four of the nine Maguindanao seedlings which were inoculated with wilt bacteria by hypodermic injection into

the midrib of an actively growing heart-leaf. Note the two wilted plants in the foreground. The other two plants in the same pot did not show the wilt symptoms.

b. Check plants.

FIG. 2. Potted Maguindanao seedlings inoculated with wilt bacteria by hypodermic injection into the upper portion of the pseudostem. Two of the plants showed signs of wilting and shriveling of the leaves as a result of infection by the wilt bacteria. About X $\frac{1}{3}$.

PLATE 14

Section of a leaf of one of the abacá suckers inoculated by hypodermic injection with wilt bacteria, showing the typical rusty-brown linear-streaks symptoms of wilt disease on the leaf blade. Only a portion of the leaf is shown as the drawing of the entire leaf was too large for this plate. The leaf remained attached to the plant while it was being drawn. Drawing was started on February 7 and finished on February 14, 1939. All of the details shown in the drawing were those exhibited by the leaf on the day it was finished. Slightly less than X 1.

PLATE 15

FIG. 1. Longitudinal sections of abacá seedlings of the Maguindanao variety. Almost X 1.

a. Sections of seedlings inoculated by hypodermic injection into the upper portion of the pseudostem. Note the infection on the pseudostem and stele of the rhizome.

b. Section of one of the check plants. The tissues in this section were white immediately after cutting, but after a few minutes' exposure they began to show some browning due to the presence of oxidizing enzymes in the cells.

FIG. 2. An inoculated Maguindanao abacá showing a black patch of rotting tissues at the base of the pseudostem. This plant was inoculated on December 3, 1938 by injecting a water suspension of wilt bacteria into the midrib of the rolled heart-leaf. Typical linear-streaks symptom of wilt disease on the central leaf was produced after seven weeks. Slightly more than X 1.

FIG. 3. The same plant shown in fig. 2, cut longitudinally to show the internal infection. Note the discolored vascular strands and rotting tissues along them. About X 1.

PLATE 1.

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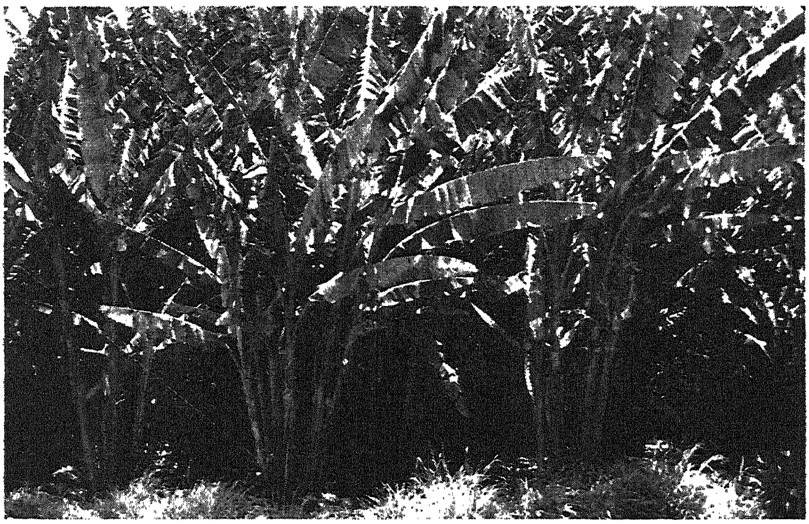

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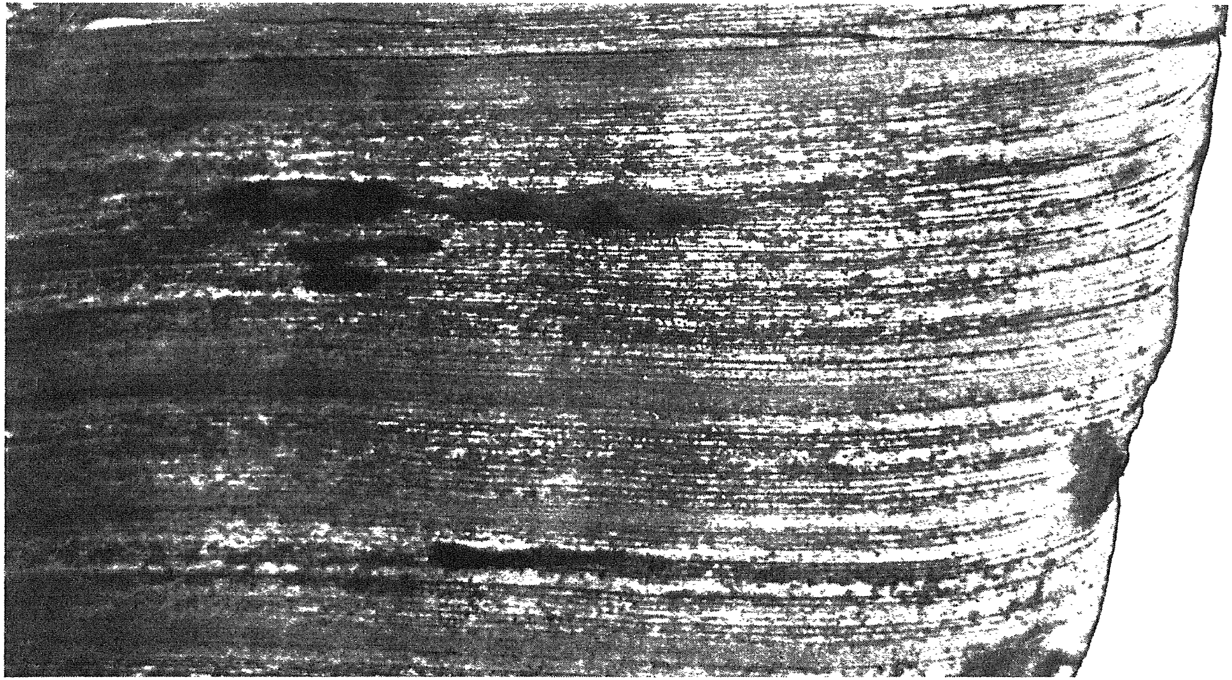
PLATE 2.

PLATE 3.

PLATE 4.



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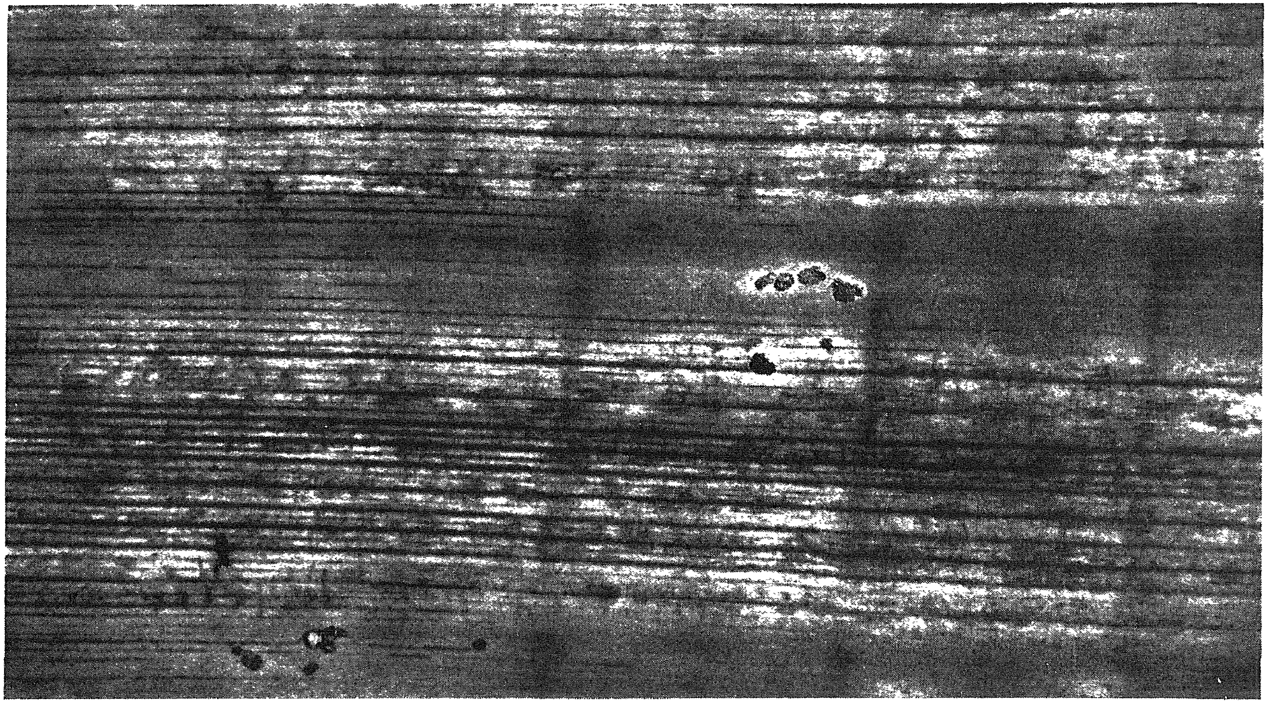

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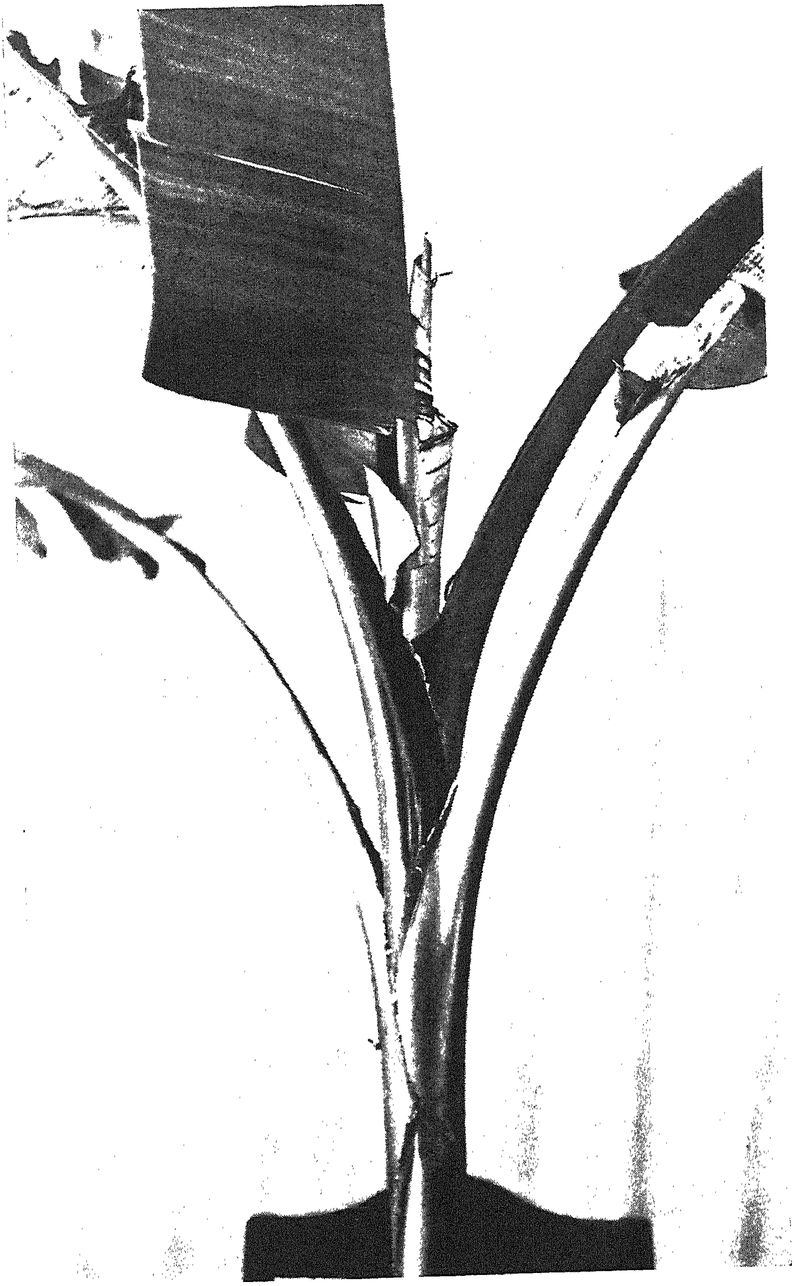

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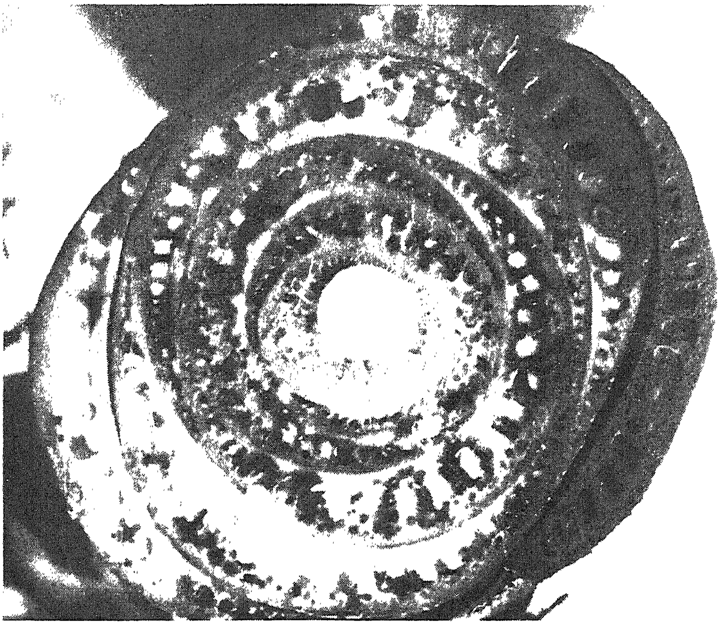

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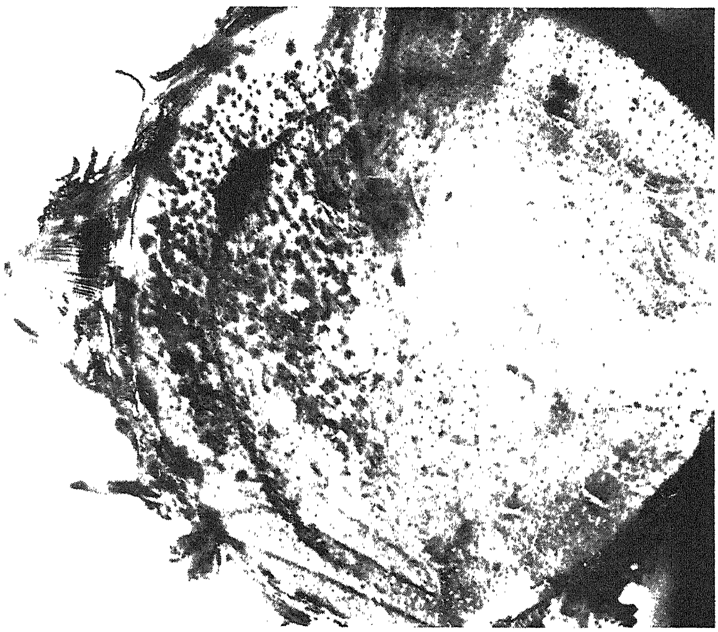

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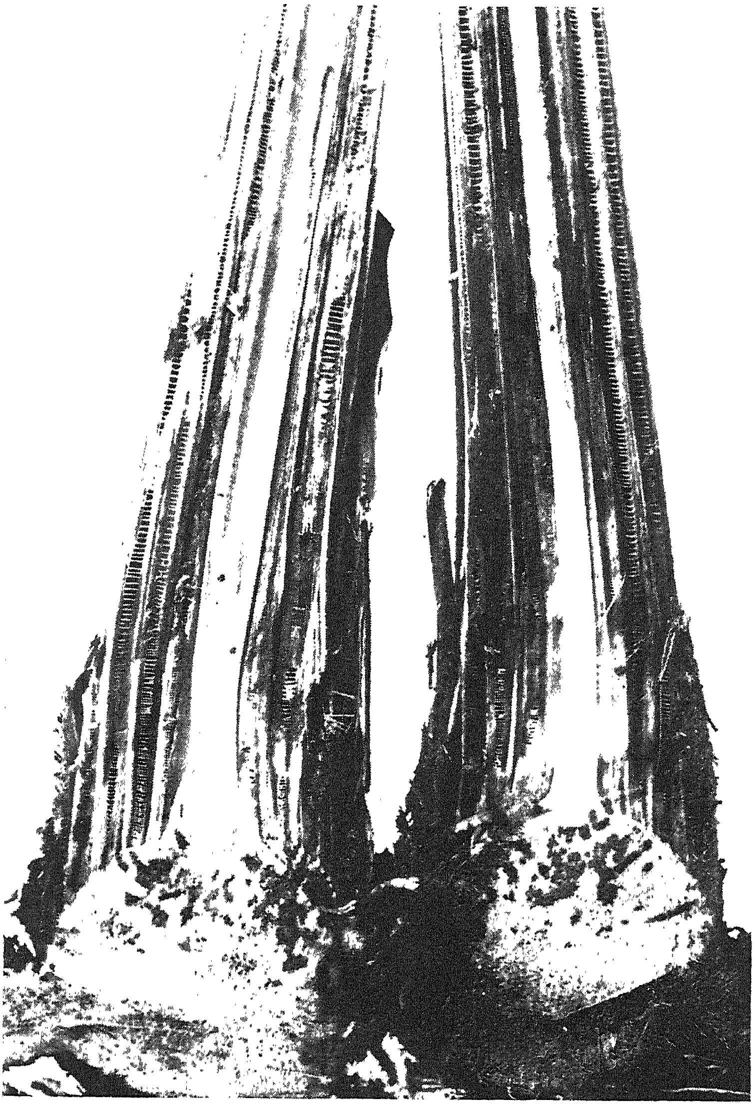
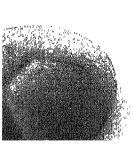


PLATE 10.

PLATE 11.



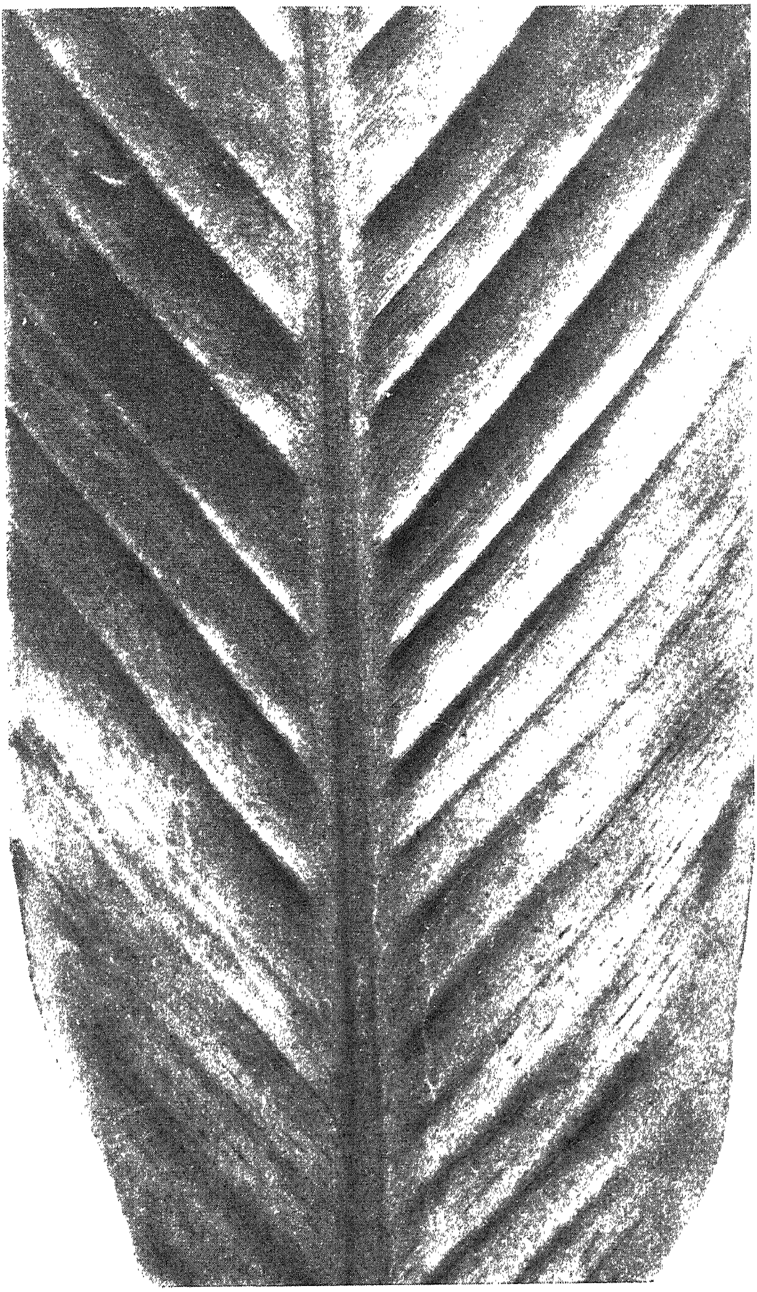


PLATE 12.

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PLATE 13.

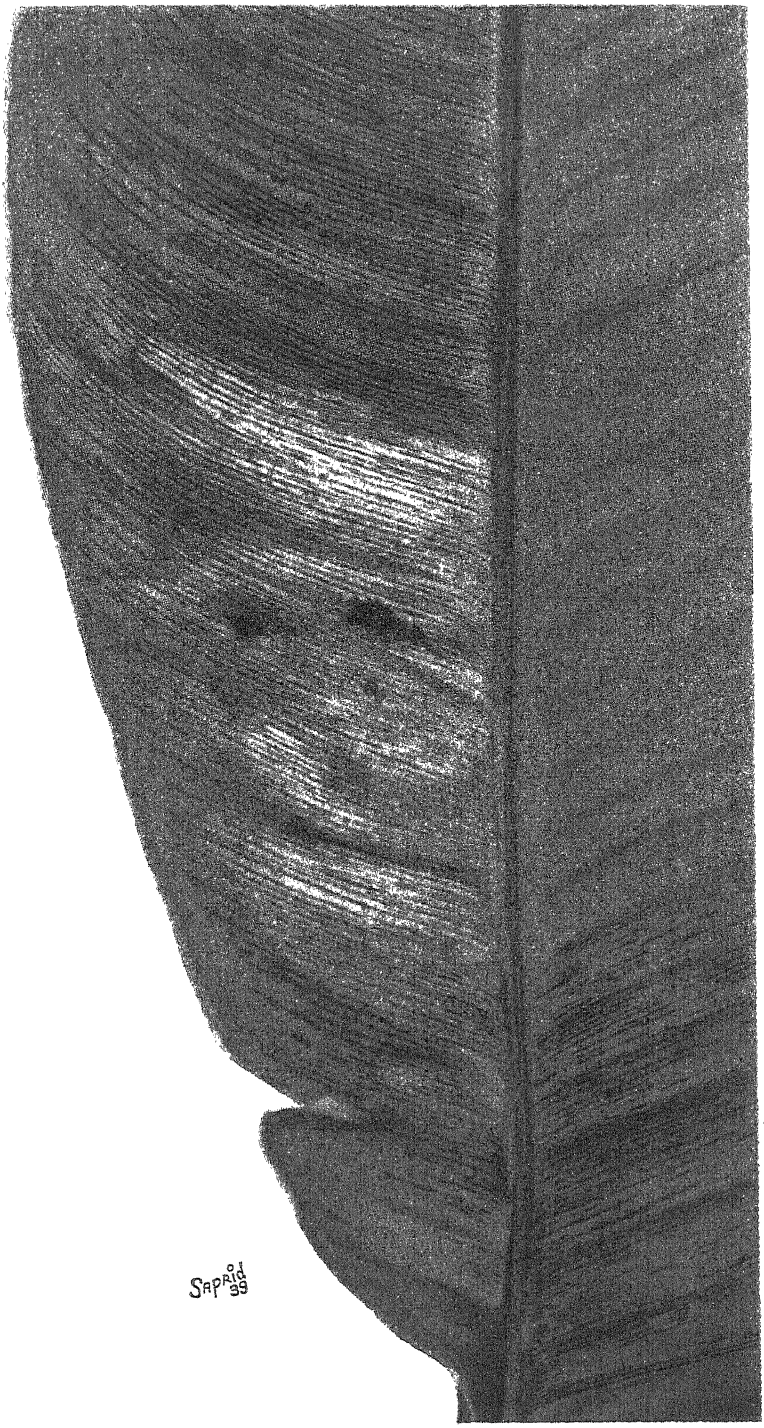

PLATE 14.

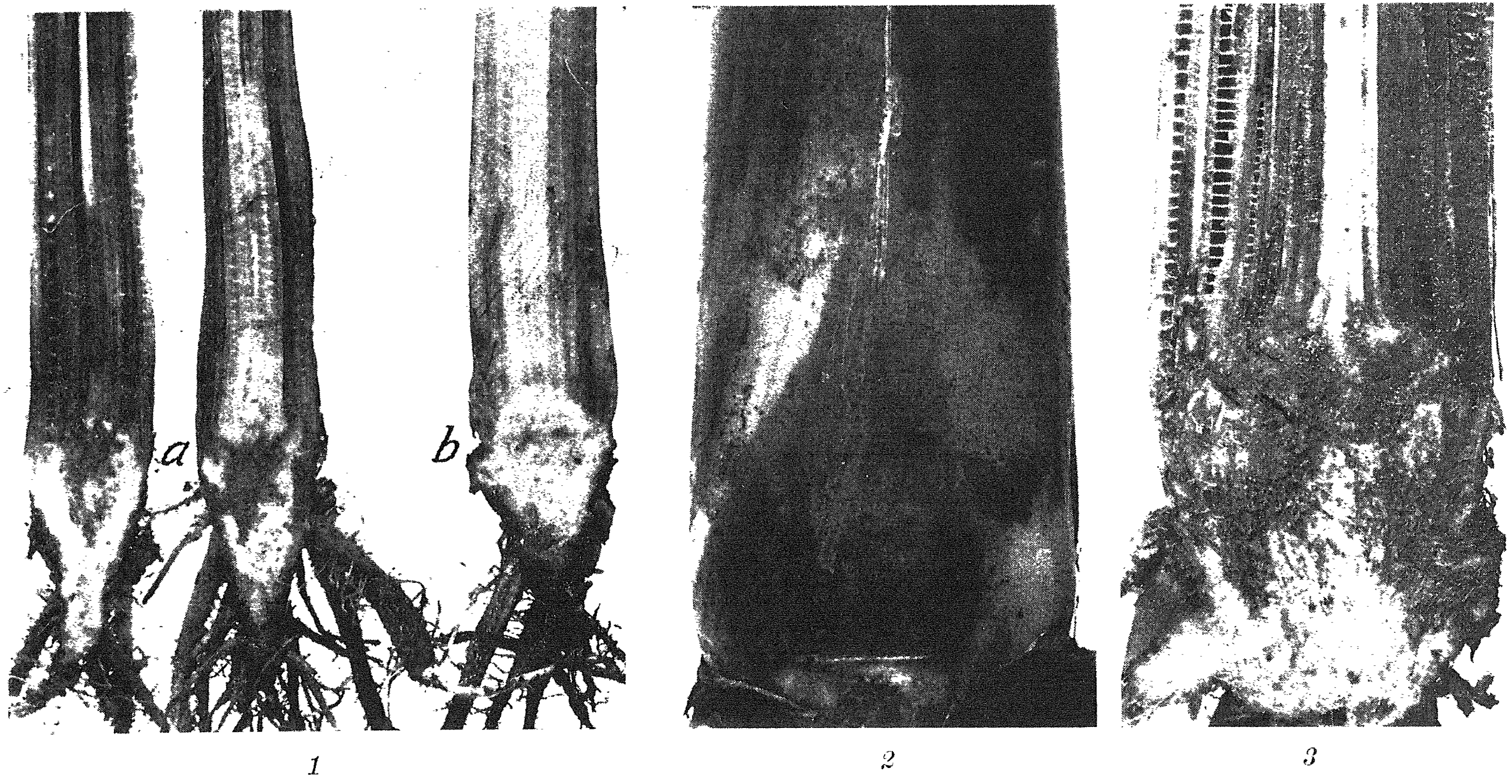

PLATE 15.

NOTES ON THE PRELIMINARY CULTURAL TRIAL WITH CHINESE WATER CHESTNUTS (*ELEOCHARIS TUBEROSA* SCHULTES)

By NICANOR G. TEODORO and FILEMON Q. ABAYA

Of the Los Baños Economic Garden
Bureau of Plant Industry

EIGHT PLATES

The Chinese water chestnut (*Eleocharis tuberosa* Schultes) is a perennial sedge which is widely cultivated in China, under the names "ma-ti", "o-yu", and "po-tsai".[1] This plant is known in the Philippines as "apulid sungsung." The tubers are dark-colored and small, measuring from 2 to 3 centimeters in diameter. They are boiled and eaten as a vegetable. The plant is closely related, as the generic name indicates, to the native apulid (*Eleocharis dulcis* Burn. f. Trin.) which is found growing in swamps and flooded rice fields in the Philippines. The native apulid, however, is smaller than the "apulid sungsung." The present paper is a report covering the results of the authors' preliminary study on the culture of "apulid sungsung."

Last year, the Economic Garden received two lots of Chinese water chestnut tubers. One lot, consisting of only eight tubers, was brought in on March 21, 1938 by Mr. Filemon Q. Abaya who obtained the tubers from a relative who had returned home from Hongkong, China; and another lot, of sixty-three tubers, was received on July 6, 1938, from the Central Office of the Bureau of Plant Industry in Manila, which imported same from China.

These two lots furnished the materials for our cultural studies on this particular plant.

For convenience the first lot is designated as Lot 1 and the second, as Lot 2.

Lot 1.—On March 23, 1938, all the eight tubers were planted in a seed box containing ordinary garden soil. On March 29, 1938 only six tubers germinated. On May 4, 1938 the young

[1] A Dictionary of the Economic Products of the Malay Peninsula 1 (1935) p. 907.

plants were transferred into the earthern pots containing ordinary garden soil. On May 17, 1938 all the pots were placed in a previously prepared rice paddy near the nursery shed where they were kept submerged in water. After a week the plants were noticed to be producing young suckers, and so, on June 1, 1938, all the six plants were removed from the pots and transplanted into the mud of the same rice paddy. At the time of transplanting the height of the mother plants was about 80 centimeters, while the suckers were about 20 centimeters. On July 1, 1938, 52 young suckers were separated from the mother plants and pricked into another portion of the paddy. The distance of planting was 50 centimeters between plants. The entire planting of the material of this lot covered an area of 20 square meters (plate 1, fig. 1).

The plants flowered on August 7, 1938, and about two weeks from flowering, the tubers became ready for harvesting.

On October 25, 1938, when the plants, numbering 563, were about 80–100 centimeters high (plate 1, fig. 2) the tubers were harvested, yielding a total number of 1,142 tubers (plate 2, fig. 1) weighing 15 kilos, or an average of 76 tubers per kilo.

Lot 2.—On July 7, 1938, all the tubers were planted as follows: 25 tubers were sown in a seed box containing ordinary garden soil, while 38 tubers were sown on a raised bed (10 cm. high) prepared in a corner of another rice paddy near the cage of the giant toad in the Systematic Garden, Field A. This paddy is partly shaded by acacia trees growing nearby; however, owing to lack of available land this paddy was used. On July 12, 1938, twenty tubers germinated out of the twenty-five tubers planted in a seed box, and only twenty germinated out of the thirty-eight tubers planted in the raised bed. In both cases, those tubers which failed to germinate were found decaying. On August 5, 1938, all the young plants were transplanted into the mud of the same paddy. The plants were planted 50 centimeters apart.

On January 13, 1939, a total of 437 tubers, weighing 5.5 kilos, was harvested when the plants were about 80 centimeters high.

During the progress of this preliminary study, the authors' attention was directed to the gross study of the methods of reproduction of this exotic plant, with the end in view of determining how best it can be propagated and how rapidly it can be multiplied under Los Baños conditions. During harvesting great care was exercised in digging out the plants and

removing the tubers from the mud, so as to prevent the stolons from breaking apart and so as to keep the tubers intact. In this way, it became possible to determine the number of culms or plants which were connected together by horizontal stolons anastomosing in the soil. It was found that several culms numbering from three (plate 6) to seven or more (plate 7), were connected by stolons.

Two kinds of stolons were observed, namely, a stolon-producing tuber (plate 3; plate 4, fig. 1; and plate 5, fig. 1), and a stolon-producing plant or culm (plate 3 and plate 6, fig. 2).

The stolon-producing tuber is characterized by the swelling of its free end which is markedly noticeable even at the beginning of the emergence of a young stolon from the base of the culm as may be seen in plate 3, fig. 1. And as the stolon elongates this protuberance becomes bigger and bigger as shown in plate 3, fig. 2, plate 4, fig. 1, and plate 5, fig. 1, until finally it assumes the size and shape of a tuber as shown in the various plates and figures. A mature tuber (plate 3, fig. 2, indicated by middle arrow; and plate 6, fig. 2, tuber at left) remaining in the soil germinates and produces a culm. While the stolon-producing tubers are normally produced from the bases of the culm, still there are some stolon-producing tubers which spring from the body of a horizontal stolon as indicated by an arrow in plate 4, fig. 2.

The stolon-producing culm or plant is characterized by a sharp free end, without any protuberance, in contrast with the stolon-producing tuber. This characteristic is distinctly shown even at the incipient growth of this kind of stolon as indicated by the left and lower arrow in plate 3, fig. 1, and by the left and upper arrow in plate 3, fig. 2. The stolon-producing culms or plants are well illustrated in plate 4, fig. 1 by a small culm developing at the extreme right of the figure, and in plate 5, fig. 2, by the several secondary plants developing from the mother culms or plants.

Under the methods of propagation described above, two or three crops were harvested from the original planting. The first crop (plate 8, fig. 1–A & B) produced the largest number of tubers (plate 1, fig. 3), while each of the second and third crops (plate 8, figs. 2 and 3) produced shorter culms and smaller quantities of tubers, respectively.

After removing the tubers from the clumps, there were found secondary stoloniferous growths, and believing that these

clumps bearing such growths could be utilized for further propagation, the tops of the stalks or culms were cut off, leaving about a foot of same with the clumps as shown in plate 2, fig. 2, and the same was set aside for the purpose above mentioned.

Using the materials obtained from this preliminary trial, a more extensive study on the culture of "apulid sungsung", such as the determination of the comparative yield of the tubers versus the clumps, and the planting of cured tubers at various intervals, etc., are underway. The results of this study will be embodied in the next more or less comprehensive report by the present authors.

ILLUSTRATIONS

PLATE 1

FIG. 1. A paddy of Chinese water chestnut (*Eleocharis tuberosa* Schultes).
2. Several clumps of Chinese water chestnut, showing tubers.
3. A close-up view of fig. 2.

PLATE 2

FIG. 1. Newly harvested tubers of Chinese water chestnut ready for the market, or for curing for future planting.
2. Clumps of Chinese water chestnut to be used for planting. Note that the tubers and tops had been removed.

PLATE 3

FIG. 1. A close-up view of four clumps of Chinese water chestnut ready for planting. Note the germinating stolons, or rhizomes.
2. Two clumps of Chinese water chestnut connected by a stolon. Note the mature tubers and two young stolons—a stolon-producing clump, characterized by a pointed free end (pointed by an arrow at top left corner), and a stolon-producing tuber, characterized by a swollen free end (pointed by an arrow at lower left side of the figure).

PLATE 4

FIG. 1. A clump of Chinese water chestnut, showing a young stolon-producing tuber (at left), and a stolon-producing clump or plant (at right). Note the four mature stolon-producing tubers.
2. Two clumps of Chinese water chestnut connected by a stolon. Note the two stolon-producing tubers arising from the body of the stolon at the point indicated by an arrow.

PLATE 5

FIG. 1. A clump or stool of Chinese water chestnut showing young stolon-producing tubers.
2. Three clumps or stools of Chinese water chestnut, showing young plants arising from the bases of the parent clumps or plants.

PLATE 6

FIG. 1. A mature Chinese water chestnut plant, showing stolon-producing tubers and a stolon-producing clump or plant at right of the figure.
2. A mature Chinese water chestnut plant, showing stolon-producing tubers. Note at left side of the figure a long stolon bearing a tuber which in turn is producing a new plant or clump.
3. Three clumps or plants of Chinese water chestnut connected together by stolons.

PLATE 7

FIG. 1. Three clumps or plants of Chinese water chestnut with their connecting stolons.

2. Several clumps or plants of Chinese water chestnut showing their connecting stolons. Note how one clump or stool or mother plant can produce several clumps or stools. (From three to seven or more stolon-producing clumps or stools or plants, and several stolon-producing tubers).

PLATE 8

FIG. 1. (A) A bunch of mature Chinese water chestnut plants representing the mother plants or those produced by the originally planted tubers. Note the height of the culms and the heavy production of tubers. (B) Close-up view of (A).

2. (A) A bunch of mature Chinese water chestnut plants representing the first offspring of the mother plants. (B) Close-up view of (A).

3. A bunch of mature Chinese water chestnut plants representing the second or third generation of plants. (B) Close-up view of (A).

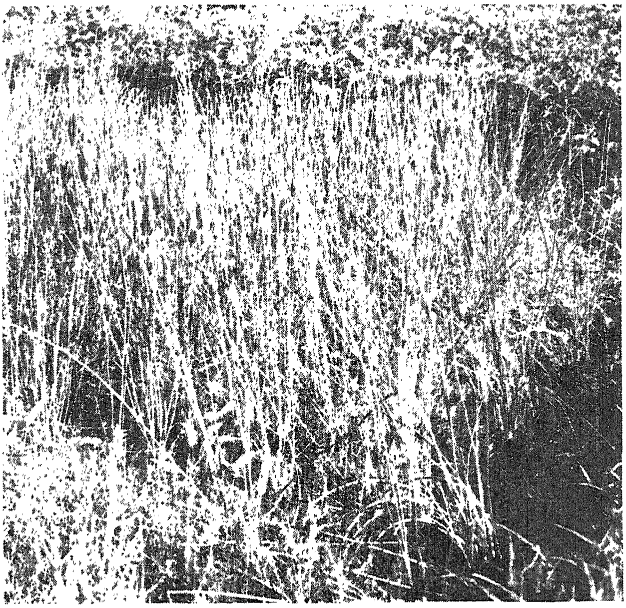

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PLATE 1.

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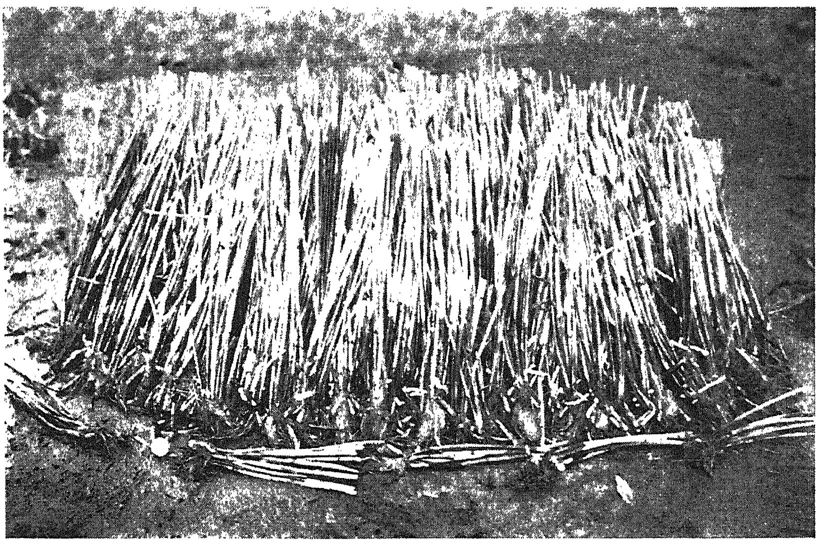

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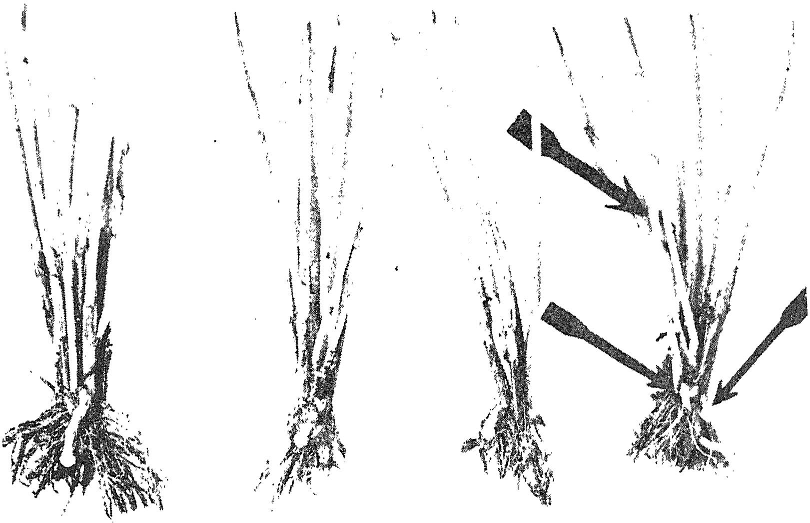
PLATE 2.



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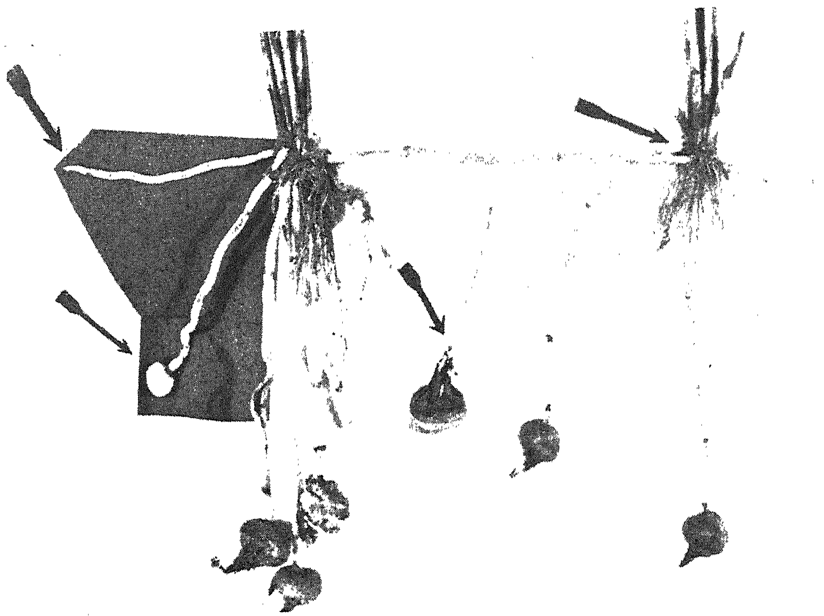

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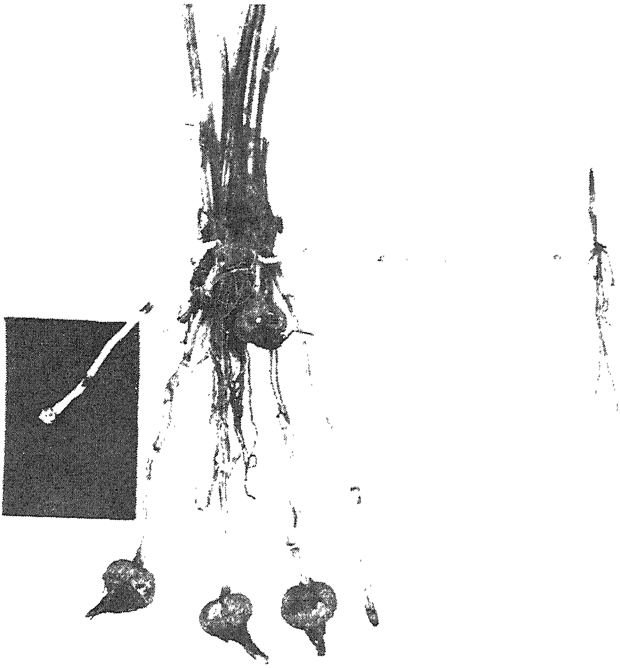
PLATE 3.



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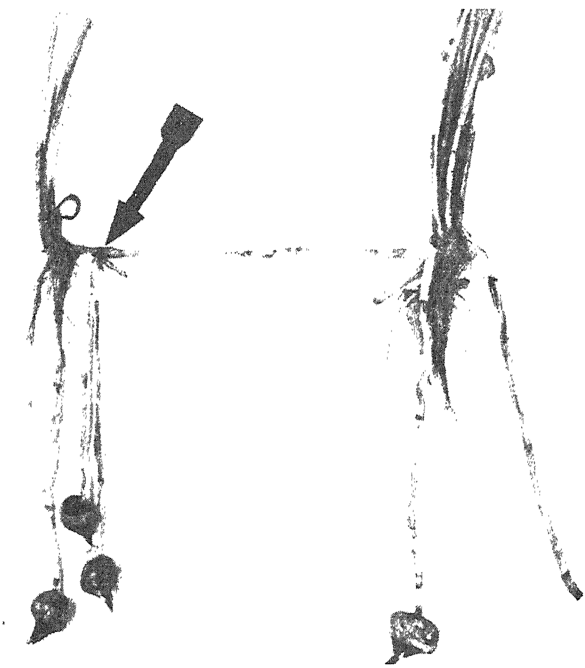

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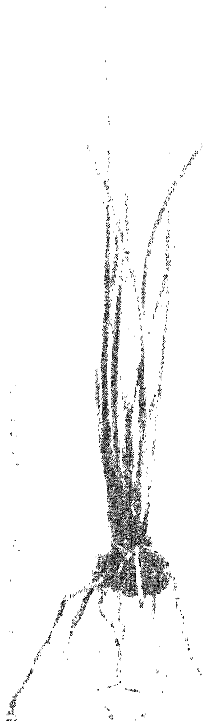
PLATE 4.



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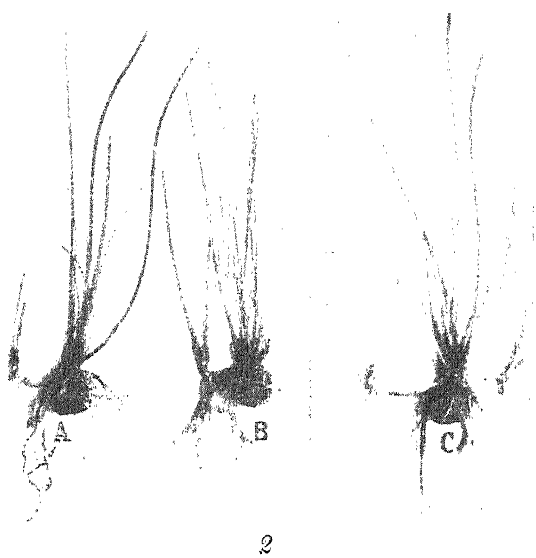

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PLATE 5.

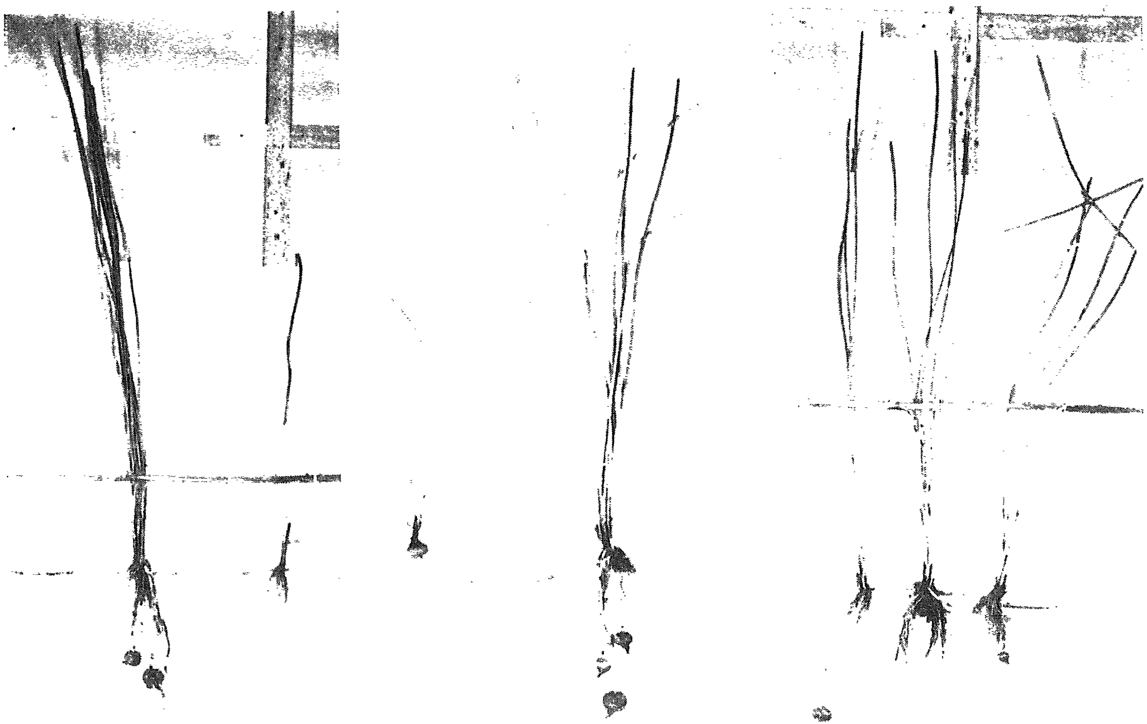

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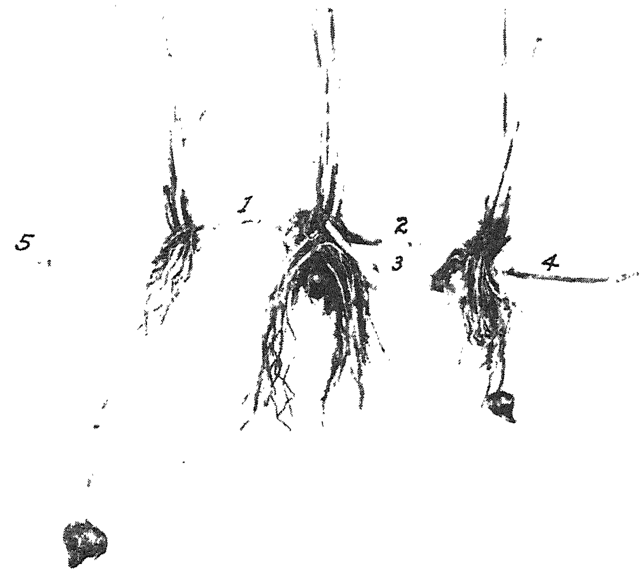
PLATE 6.



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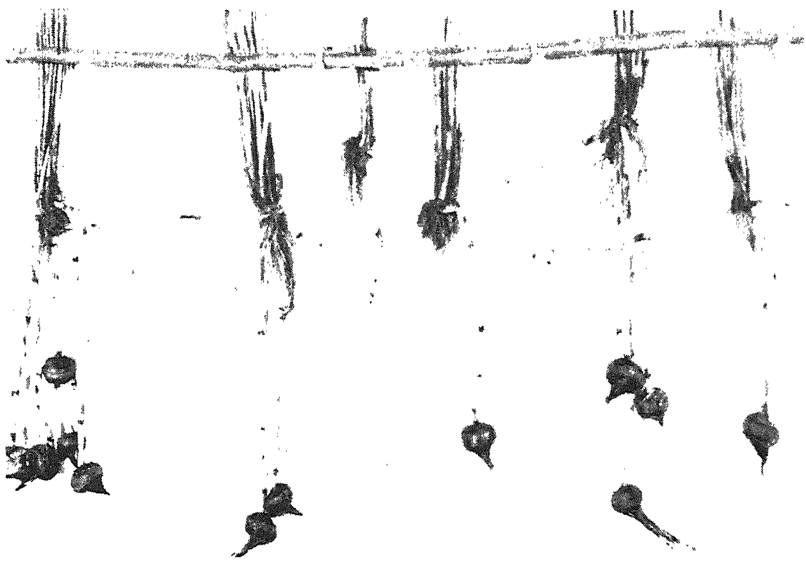

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PLATE 7.

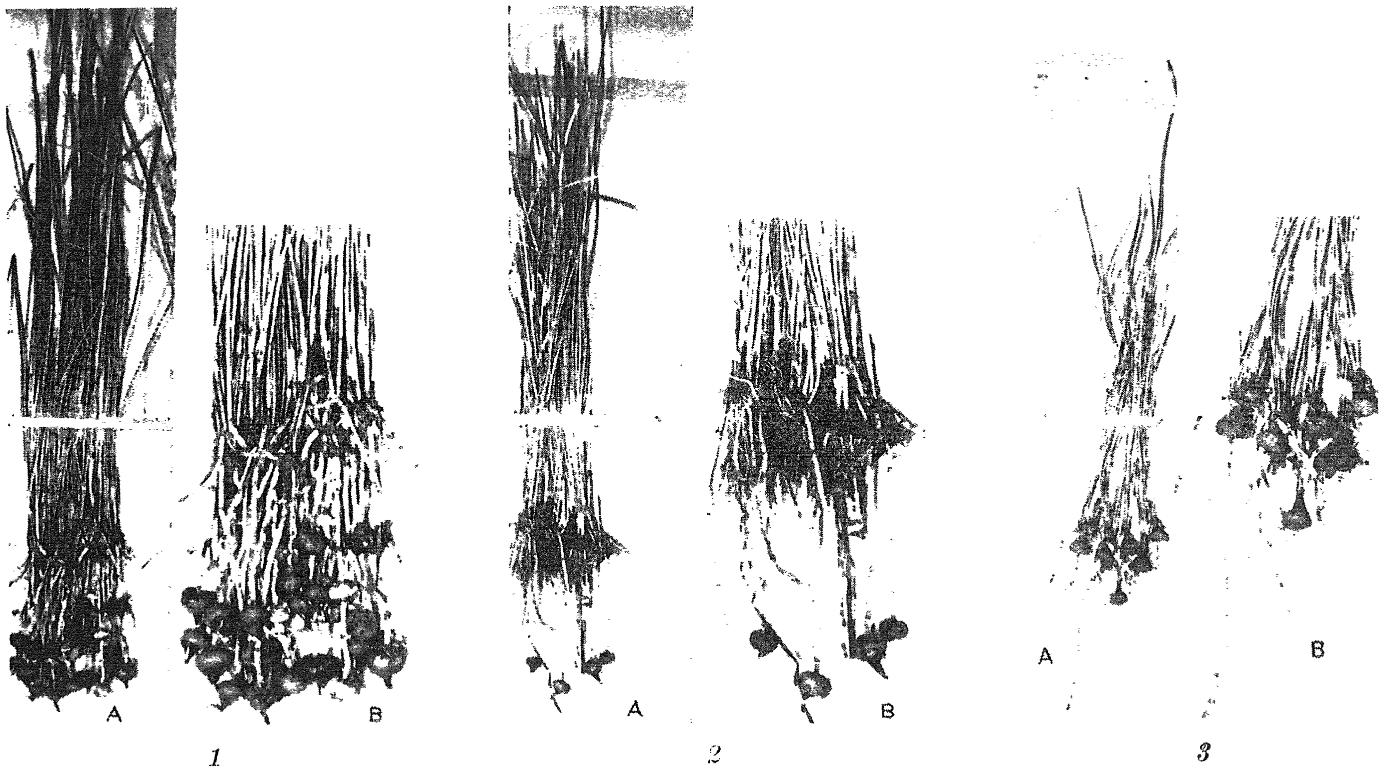

PLATE 8.

FURTHER ACCLIMATIZATION STUDIES ON CAULIFLOWER

By P. A. RODRIGO
Of the Horticulture Section, Bureau of Plant Industry

TWO PLATES

The first successful attempt in the Philippines to grow cauliflower at sea level was first reported in 1934.[1] In this report, Early Patna was the only variety that produced curd (head) successfully out of a number of varieties tried. The curd of this variety, however, as grown locally is comparatively small and not so compact and solid as that imported from the United States and Australia. Nevertheless, this was considered a distinct contribution to the development of the local vegetable industry, and as a result, the culture of cauliflower has been gaining in popularity in different parts of the Islands.

It is in the interest of this growing industry, coupled with the desire to see cauliflower become a common article of food and not only a delicacy, that the present work was undertaken, which had as its main objective the search for some varieties of cauliflower that are superior to the Early Patna variety.

This study was conducted at the Central Experiment Station of the Bureau of Plant Industry, Malate, Manila. The first set of culture was started in September, 1934, and the last test was harvested in February and March, 1939.

MATERIALS AND METHODS

In this study, 19 varieties of cauliflower were used, including Early Patna, which was used as the standard. These varieties were imported from the United States, Great Britain, India, and the Federated Malay States. The different varieties were not all cultured at the same time; some varieties were tested only once for obvious reasons, while others were cultured two or more times. Where a variety was tested more than once, seeds of this variety were imported every season from the same seed house. Eight separate cultures were made during a period of five vegetable seasons. The varieties tested and their countries of origin are listed in table 1.

---

[1] Rodrigo, P. A., P. S. Urbanes, and P. Hernaiz. A progress report on the acclimatization of cauliflowers, 1933–1934. Phil. Jour. Agr. 6 (1934) 115–127.

TABLE 1.—*Showing the varieties tested and the countries of origin.*

Variety Name	Origin
Burpeana	W. Atlee Burpee Co., Philadelphia, Pa., U. S. A.
Burpee's Fordhook	W. Atlee Burpee Co., Philadelphia, Pa., U. S. A.
Burpee's Ideal Snowball	W. Atlee Burpee Co., Philadelphia, Pa., U. S. A.
Chinese	Obtained locally but originally from China
Dry Weather	W. Atlee Burpee Co., Philadelphia, Pa., U. S. A.
Early Benares	Sutton & Sons, Ltd., Calcutta, India
Early Italian Giant	Steckler Seed Co., Inc., New Orleans, U. S. A.
Early Market	Sutton & Sons, Ltd., Calcutta, India
Early Patna	Sutton & Sons, Ltd., Calcutta, India
Early Snowball	Steckler Seed Co., Inc., New Orleans, U. S. A.
Henderson's Primosnow	Peter Henderson & Co., New York, N. Y., U. S. A.
Henderson's Snowball	Peter Henderson & Co., New York, N. Y., U. S. A.
Large Algiers	Steckler Seed Co., Inc., New Orleans, U. S. A.
Maincrop Benares	Sutton & Sons, Ltd., Calcutta, India
Maincrop Patna	Sutton & Sons, Ltd., Calcutta, India
Merveille de Tout Saison	Kuala Lumpur, Federated Malay States
Sutton's All the Year Round	Sutton & Sons, Ltd., Reading, England
Sutton's Improved Snowball	Sutton & Sons, Ltd., Reading, England
Sutton's White Queen	Sutton & Sons, Ltd., Reading, England

In all the cultures, the seedlings were set in two-row beds, 50 centimeters between the rows and 60 centimeters between the plants. All the plots were fertilized with nitrophoska (16.5–16.5–20) at the rate of 300 kilograms per hectare. The fertilizer was applied just before planting and thoroughly mixed with the soil in the holes made for the reception of the seedlings.

All the cultures were regularly weeded and cultivated. When the seedlings were well started in their growth, they were twice dressed with ammonium sulphate at the rate of 80 kilograms per hectare. The cultures were watered in such a way as to keep the soil moist all the time. The irrigation was done by

letting the water flow between the rows of cauliflower. To control repressive agencies, particularly cabbage worms, the plants were regularly sprayed with soap and Imazu insect powder. As much as possible, the different varieties were treated in practically the same way, especially those that were cultured at the same time.

Several cultures were undertaken from 1934 to 1939—three cultures during the 1934–1935 vegetable season, one during the 1935–1936 season, two during the 1936–1937 season, one during the 1937–1938 season, and another one during the 1938–1939 season.

EXPERIMENTS AND RESULTS

Cultures of the 1934–1935 vegetable season.—As already stated, three sets of plantings were made, one in the month of September, another in October, and the last in December. The stand of the three cultures was good. Besides Early Patna, two new varieties produced heads. The results of these tests are summarized in table 2.

TABLE 2.—*Results of the cauliflower acclimatization test in 1934–1935*

Variety name	Area of plot	Per cent heading	Actual yield	Average weight per head	Computed yield per hectare	Relative ield
	Sq. m.		*Kg.*	*Gm.*	*Kg.*	*Per cent*
		1st planting—Sept. 24, 1934				
Early Patna	12	76.8	4.396	102	3,663.2	100
Early Benares	24	75.9	7.323	86	3,050.8	83
Maincrop Patna	24	33.0	3.427	92	1,427.7	39
Maincrop Benares	12	0				
		2nd planting—Oct. 23, 1934				
Early Patna	31	89.8	17.287	150	5,575.0	100
Early Benares	31	56.3	8.301	113	2,676.9	48
Maincrop Patna	24	46.0	5.193	117	2,162.8	39
Maincrop Benares	24	0				
Chinese	24	0				
		3rd planting—Dec 8, 1934				
Early Patna	30	73.8	9.898	106	3,299.1	100
Early Benares	20	60.7	6.189	121	3,094.3	94
Maincrop Patna	20	15.5	0.974	75	486.8	15
Maincrop Benares	20	0				
Henderson's Primosnow	20	0				
Henderson's Snowball	20	0				
Sutton's All the Year Round	20	0				
Sutton's Improved Snowball	20	0				
Sutton's White Queen	20	0				
Chinese	20	0				

1935–1936 culture.—Four varieties were the subject of this study. All of them were able to produce curds. The results obtained are summarized in table 3.

TABLE 3.—*Results of cauliflower acclimatization test in 1935–1936*

Row number[1]	Variety			
	Merveille de Tout Saison	Early Patna	Early Benares	Early Market
	Kg.	*Kg.*	*Kg.*	*Kg.*
1	0.27	0.95	0.68	1.48
2	0.48	0.87	0.31	1.27
3	0.27	0.85	0.75	2.02
4	0.47	1.10	0.83	1.69
Mean	0.37±0.03	0.94±0.03	0.64±0.04	1.61±0.09
Standard deviation	0.10±0.02	0.098±0.02	0.12±0.03	0.28±0.06
Coefficient of variability	27.02±6.84	10.42±2.49	18.75±4.53	17.39±4.18
Computed yield per hectare	587.3	1,492.1	1,015.9	2,555.6
Relative yield	39.1	100	68.1	171.3
Per cent heading	66.2	96.2	88.5	96.3

[1] Length of row was 12.6 meters, equivalent to 6.3 sq. m. The plots were prepared as raised beds.

1936–1937 culture.—Two sets of planting were made. In one of the cultures, three varieties were tested and in the other, only two were cultured. Tables 4 and 5 present the summarized results of these tests.

TABLE 4.—*Results of the 1936–1937 cauliflower test*

Row number[1]	Early Patna	Early Benares	Early Market
	Kg.	*Kg.*	*Kg.*
1	2.78	2.82	3.48
2	2.28	3.01	3.74
3	2.51	1.69	3.16
4	2.56	1.87	2.98
5	2.20	1.64	2.25
Mean	2.46±0.06	2.21±0.17	3.12±0.15
Standard deviation	0.21±0.04	0.58±0.12	0.51±0.11
Coefficient of variability	8.53±1.82	26.24±5.94	16.34±3.47
Computed yield per hectare	4,100	3,683.3	5,200
Relative yield	100%	89.8%	126.8%

[1] Each row was 12 meters long or equivalent to 6 sq. meters.

TABLE 5.—*Comparative yields of the two best-yielding cauliflower varieties under local conditions*

Plot number [1]	Early Patna	Early Market
	Kg.	*Kg.*
1	4.42	8.04
2	4.49	5.90
3	4.77	5.75
4	4.03	4.01
5	5.66	6.46
6	5.67	6.98
7	5.43	5.20
8	3.40	5.79
Mean	4.73±0.18	6.01±0.26
Standard deviation	0.76±0.13	1.12∓0.18
Coefficient of variability	16.17±3.57	18.63±4.53
Yield per hectare	4,457.1	5,723.8
Per cent heading	96.8	97.6

[1] The plot had an area of 10.5 sq. m. (1 x 10.5 m.)

1937–1938 test.—This culture included seven varieties, four of which were newly introduced. The summary of the results of this study is presented in table 6.

TABLE 6.—*Results of the cauliflower test during the 1937–1938 season* [1]

Variety name	Heading	Mean yield [2]	Computed yield per hectare	Relative yield
	Per cent	*Kg.*	*Kg.*	*Per cent*
Early Patna	80	1.95±0.15	4,875	100
Early Market	100	3.78±0.09	9,450	193.8
Early Benares	71.7	1.64±0.17	4,100	84.1
Burpeana	13.4	0.30±0.01	750	15.4
Burpee's Fordhook	0			
Burpee's Ideal Snowball	13.4	0.17±0.01	422	8.7
Dry Weather	13.4	0.13±0.01	322	6.6

[1] Mr. A. L. Tecson of the Horticulture Section assisted in conducting this test.
[2] Average of 2 to 4 replications.

1938–1939 culture.—Eight varieties were cultured in this test, two of which were tested here for the first time. Table 7 presents the summary results of this test while table 8 is a summary of tables 2, 3, 4, 5, 6, and 7.

TABLE 7.—*Results of the 1938–1939 cauliflower acclimatization test*[1]

Variety name	Heading	Average weight per head	Computed yield per hectare[2]
	Per cent	*Gm.*	*Kg.*
Burpeana	0		
Dry Weather	0		
Early Benares	51	197.95±10.72	2,804
Early Italian Giant	0		
Early Market	82	165.50± 9.90	3,770
Early Patna	78	198.10± 8.47	4,292
Early Snowball	0		
Burpee's Ideal Snowball	0		
Large Algiers	0		

[1] Mr. J. M. Ilagan of the Horticulture Section assisted in conducting this test.
[2] The yield per Ha. was computed on the basis of 27,777 plants per Ha.

TABLE 8.—*Average yields per hectare of different varieties of cauliflower (Summary of tables 2, 3, 4, 5, 6, and 7)*

Variety name	Number o tests made	Days to maturity	Heading	Yield per hectare	Relative yields
			Per cent	*Kg.*	*Per cent*
Early Patna (Standard)	8	81–110	84.9	3,971	100
Early Benares	7	88–113	67 8	2,718	73
Maincrop Patna	3	94–120	31.5	1,359	32
Maincrop Benares	3		0		
Henderson's Primosnow	1		0		
Henderson's Snowball	1		0		
Sutton's All the Year Round	1		0		
Sutton's Improved Snowball	1		0		
Sutton's White Queen	1		0		
Chinese	2		0		
Merveille de Tout Saison	1	77-113	66.2	587	15
Early Market	5	82–106	94.7	5,366	133
Burpeana	2	132–133	6.7	375	9
Burpee's Fordhook	1		0		
Burpee's Ideal Snowball	2	104–108	6.7	211	5
Dry Weather	2	105-116	6.7	161	4
Early Italian Giant	1		0		
Early Snowball	1		0		
Large Algiers	1		0		

DISCUSSION OF RESULTS

The results of this study brought out some information that should prove interesting and valuable, not only to gardeners in the Islands, but also to those who are interested in the improvement and development of the local vegetable industry. All the varieties tested produced normal and healthy plants, but they greatly differed in their ability to produce curd, or head.

1934–1935 cultures.—During the 1934–1935 vegetable season, nine varieties were tested, four of which having been subjected to two or more tests made in different months. Of these nine varieties, two produced heads. These were Early Benares and Maincrop Patna; they both produced heads in all the three sets of cultures. Early Benares had a heading percentage of from 56.3 to 75.9, while Maincrop Patna gave a heading of from 15.5 to 46.0 per cent. Early Benares produced bigger and better heads but these were not as good as those of the Early Patna.

The other varieties tested failed to produce any head in spite of their good vegetative development. With respect to this, special mention may be made of Sutton's All the Year Round, which had a very good vegetative development. The plants of this variety were of medium size but very uniform, low, stocky, with broad and numerous leaves—all these being suggestive of big, compact, and well-protected heads. This variety, however, failed to produce any head.

1935–1936 test.—With the two heading varieties in the previous season, two new ones were included in this year's culture. These were Merveille de Tout Saison, a variety claimed to have been bred to suit Kuala Lumpur (Federated Malay States) conditions[1], and Early Market, a new introduction from India. Both of these varieties produced heads, the former registering 66.2 per cent heading and the latter giving 96.3 per cent heading. Early Market gave a much higher yield of head per unit area than did Merveille de Tout Saison. In fact, Early Market gave the highest yield in this culture, even outyielding Early Patna by over 70 per cent (table 3).

1936–1937 tests.—A more thorough comparison of the yielding power of the three best varieties so far found, namely, Early Patna, Early Benares, and Early Market was made. As seen in table 4, Early Market was the heaviest yielder, followed by Early Patna, and Early Benares was the poorest. The corresponding yields of 12-meter rows of these varieties were 3.12 $\pm$ 0.15, 2.46 $\pm$ 0.06, and 2.21 $\pm$ 0.17 kilograms, respectively. In table 5, it is again shown that Early Market gave a decidedly greater yield per unit area than did Early Patna, their respective yields per hectare being 5,723.8 and 4,457.1 kilograms. However, the heads of the Early Patna seemed to be more

[1] From a letter of S. M. Sharma, filed with the records of the Bureau of Plant Industry.

uniform in size than those of the Early Market, as shown by their respective coefficients of variability (tables 4 and 5).

1937–1938 culture.—As seen in table 6, three of the new varieties tested produced some heads, namely, Burpeana, Burpee's Ideal Snowball, and Dry Weather. The percentage of heading of these varieties, however, was very low and the heads were small and had the objectionable "ricy" appearance. On the other hand, Early Market, Early Patna, and Early Benares gave good yields as in previous tests, their respective yields in this test being 9,450, 4,875, and 4,100 kilograms per hectare.

1938–1939 culture.—This test, which included nine varieties, did not reveal any new finds. On the other hand, such varieties like Dry Weather, Burpeana, and Burpee's Ideal Snowball, which produced some heads in the 1937-1938 culture, failed to show any sign of curding this season. Also, unlike in previous tests, Early Patna outyielded Early Market in this test. Early Benares remained third. The corresponding yields of these varieties as computed on the basis of one hectare were 4,292, 3,770, and 2,804 kilograms.

PROMISING VARIETIES

Table 8 presents a summary of the performances of the 18 varieties tested. Of these, seven varieties were able to produce some heads, but only two, namely, Early Market and Early Benares, are considered promising and would be worthwhile growing at low altitudes. The computed average yields per hectare of these varieties, as based on from 5 to 7 cultures, were 5,366 and 2,718 kilograms, respectively as compared with the 3,971 kilograms of the standard variety, Early Patna (table 8). The respective average per cent headings were 94.7, 67.8, and 84.9. Early Market was ready for harvesting in from 82 to 106 days after sowing; Early Patna, from 81 to 110 days; and Early Benares, from 88 to 113 days.

Early Market, Early Patna, and Early Benares, even to one who is quite familiar with them, would appear practically similar. Early Benares is a wee bit taller than either Early Market or Early Patna, but the last two varieties have the tendency to produce wider leaves. As a rule, however, these three varieties did not seem to be in a high degree of purity. The plants showed great variability in size, development, and maturity. The heads they produced were also very variable in size and in compactness, especially those of Early Benares. Unless the soil is very fertile, the plants, being early maturing, are apt to

head even if they are still small and have few leaves. In this case, the heads are also small, and do not have the milky white appearance which is desired in the market. In order to obtain good results, the seedlings should be raised in fertile seedbeds so that they could be transplanted within a period of four weeks. Then the field should be well supplied with thoroughly decayed stable manure or compost and properly supplemented with some commercial fertilizers.

SUMMARY

This study was undertaken during a period of five vegetable seasons, 1934 to 1939 inclusive. A total of 19 varieties (including Early Patna which was used as the standard) has been tested, and each of these was cultured from one to eight times.

Of the 18 new varieties tested, seven were able to produce some heads. These varieties are Early Benares, Maincrop Patna, Merveille de Tout Saison, Early Market, Burpeana, Dry Weather, and Burpee's Ideal Snowball. The average yields of these varieties varied from 161 to 5,366 kilograms per hectare, and the period of maturity (from sowing to harvesting) was from 77 to 133 days.

Of the seven varieties that produced heads, only two were found to compare favorably with the standard (Early Patna). These two varieties are Early Market and Early Benares. Until we can produce better varieties, Early Market and Early Benares, together with Early Patna, will constitute the commercial varieties of cauliflower for the lowlands in the Philippines.

Compared with Early Patna, Early Market outyielded the former by 33 per cent, while Early Benares was outyielded by the standard variety (Early Patna) by 27 per cent. Early Market gave an average yield of 5,366 kilograms per hectare based on five cultures; Early Patna, 3,971 kilograms as average of eight cultures; and Early Benares, 2,718 kilograms as average of seven cultures. Early Market gave an average heading of 94.7 per cent; Early Patna, 84.9 per cent; and Early Benares, 67.8 per cent.

ILLUSTRATIONS

PLATE 1

FIG. 1. A portion of the acclimatization test field (1938–1939) at the Central Experiment Station, Manila.

2. Cauliflower acclimatization plots at the La Union Provincial Nursery, Bangar, La Union.

PLATE 2

FIG. 1. A well-formed head (curd) of Early Patna.

2. A well-formed head (curd) of Early Market.

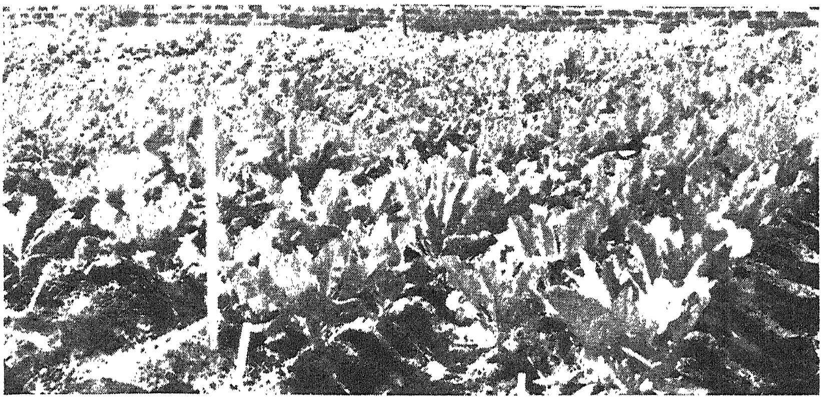

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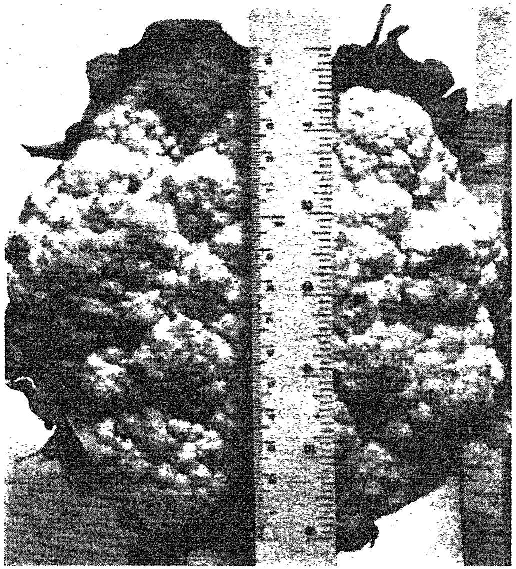
PLATE 1.



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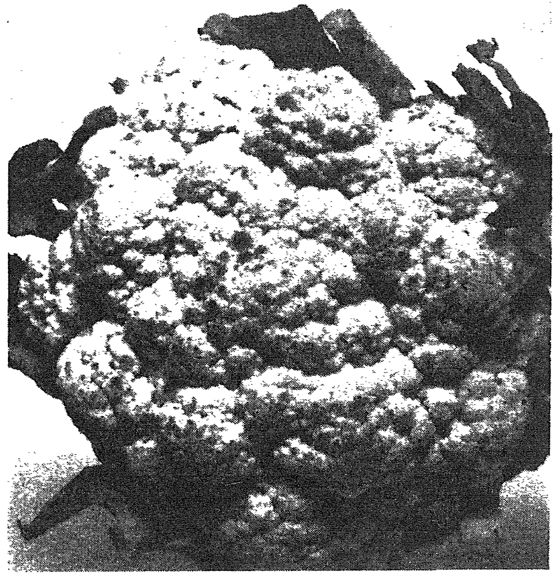

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PLATE 2.

A NEW PHYTOPHAGOUS LADY BEETLE IN THE PHILIPPINES

By SALUSTIANO S. GONZALES

Of the Plant Pest and Disease Control Division
Bureau of Plant Industry

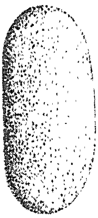
THREE PLATES

The Governor's plum or cerali, *Flacourtia indica* (Burm. f.) Merr., in the Los Baños Economic Garden, has, for some time, been seriously defoliated by a species of coccinellid beetle which, according to Dr. Fritz van Emden of the Imperial Institute of Entomology, London, England, in a letter to the writer dated January 10, 1939, is *Plagiodera metallica* Er. As far as the writer is aware, this is the first time that this species is reported in the Philippines as a pest. Both larvae and adults feed considerably on the leaves of cerali. No other hosts are so far known.

LIFE HISTORY, HABITS, AND DESCRIPTIONS

The eggs (plate 1, fig. 1) are elongatedly subovoid and greenish-yellow when newly laid. They, however, turn yellow when about to hatch. They measure about 1 millimeter long and 0.4 millimeter in cross-section. The eggs are invariably laid on either surface of the young leaves of the host plant either singly or in groups of from 2 to 27. It was observed that ovipositions took place at night. The incubation period was found to be about 3 days.

There are three instars. When newly hatched (plate 1, fig. 2), the larvae are light greenish-yellow. They measure about 1 millimeter long and 0.6 millimeter wide. The head and the pronotum are dark brown, approaching black. The legs are of the same color as the body, with dark brown joints. A pair of dark brown or black circular rings, the centers of which are of the same color as the rest of the body, is present on each side of the last two thoracic segments. There is a row of dark brown dots along the length of each side of the abdomen. Three



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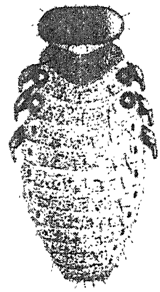

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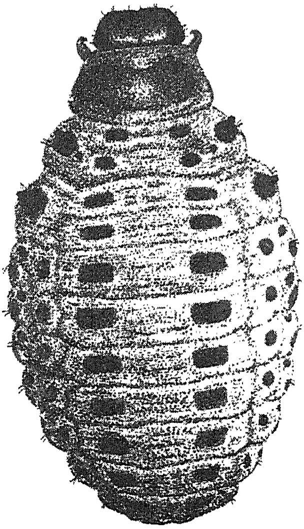

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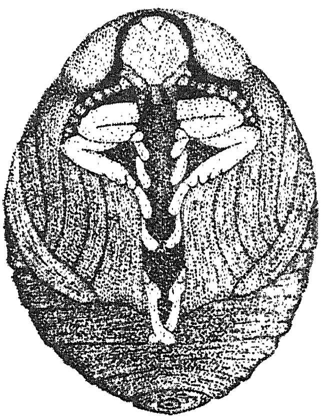

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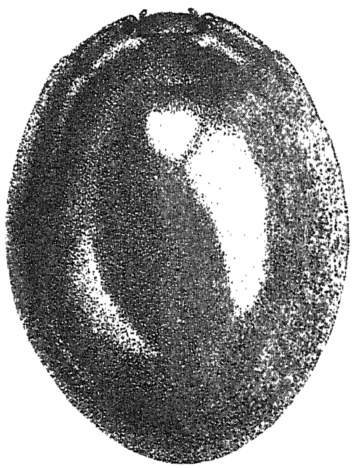

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PLATE 1.

PLATE 2.

PLATE 3.

RICE DISEASES AND METHODS OF CONTROL[1]

By Gaudencio M. Reyes

Plant Pathologist, Bureau of Plant Industry

FIFTEEN PLATES

CONTENTS

INTRODUCTION

There are several diseases attacking rice in the Philippines; some are of widespread occurrence while others are of limited distribution. Considering the scattered areas devoted to rice cultivation under varying sets of conditions and the fact that these diseases have complete freedom to multiply and spread far and wide, their actual distribution is much wider than is already known. Also, on account of the fact that rice in the Philippines grows under two distinct sets of conditions, nature has provided some means whereby the ravages from diseases are delimited. In order, however, to know clearly which diseases are actually doing more or less serious damage, and owing to the size of the industry, a yearly systematic survey of rice diseases seems necessary before we can evaluate their importance as they occur in the field. For the same reason, it is difficult to estimate with any accuracy the losses due to specific rice diseases or rice diseases taken as a whole. It is only

[1] Farmers' Circular No. 50.

safe to say, however, that they cause the loss of thousands of cavans every year. Conservatively speaking, diseases can reduce the rice crop in the Philippines by at least five per cent. Present knowledge leads us to believe that some diseases are potentially more important than others; while some may appear annually in epidemic form, others cause only sporadic outbreaks.

Rice, like other plants, may fall victim to other destructive elements without being attacked by fungus or bacterial organisms. For example, lack of water or too much water are equally detrimental to rice. Lack or excess of certain food elements are no less harmful to the rice crop. Storms and floods have caused heavy damage to rice in the Philippines many a time. Salt water and acid soil are also injurious to the rice crop. There are also other causes which, of course, find no place in this discussion.

While a thorough knowledge of the symptoms and causes of rice diseases, the conditions favoring them, methods of dissemination, etc., is the first essential asset before appreciating their methods of control, much damage can be averted by the use of clean, healthy seeds and improved cultural treatment. The most persevering worker would often lose his way if he fails to get a thorough understanding of his disease problem. This basic knowledge is very important to every rice grower, and to emerge triumphant over all possible odds "every grower must in practice be his own rice doctor." By the very nature of conditions existing in the Philippines, especially with reference to rice, the ultimate solution of our control problem seems to lie largely in immunization. On account, however, of the long and arduous task confronting a single investigator of developing resistant varieties possessing desirable agronomic and commercial traits, a great deal more still remains to be done before we can hope to see our rice crops reasonably free from the maladies generally known to be inflicting enormous damage yearly. In the absence of a thorough knowledge of the varieties or strains that can withstand the effects of various diseases extant, we must content ourselves with the available methods in vogue, even though some of them are rather expensive and can only do partial wonders. But whichever expedient method or methods are employed, the degree of success would depend in no little measure upon the community spirit.

For combating the diseases of rice in the Philippines, this illustrated treatise has been prepared as a matter of expediency

to help those who may be engaged in this kind of work, in accordance, more or less, with the order or time of the year in which the diseases generally appear. At times, however, two or more diseases may occur simultaneously, doing damage conjointly although in unequal proportions, thus aggravating a disease situation.

SEED-BORNE DISEASES

Some rice diseases are often carried on or within the seed, some of which produce various shades of discoloration on the glumes. The most common parasitic fungous diseases carried by the seed are the Fusarium (plate 1), the Helminthosporium (plate 4), the black smut (plate 10), the Piricularia, the Cercospora, and the green smut (plate 13). Upon the ability of the farmer to detect diseased seeds depend in some measure the safeguards against the introduction or multiplication of diseases in his own field. If no clean, healthy seeds are available, much trouble can be averted by resorting to the use of seed treatments.

Control.—Shocking while damp would stimulate the growth of seed-borne organisms—not only those that can cause disease but also those that are nonpathogenic. Healthy seeds of known source should be used. Diseased seeds should not be mixed with sound seeds and no seeds should be stored when not properly dried. If no sound seeds are available, disinfection should be resorted to. The hot-water treatment is recommended as a cheap method. Soak the seeds in half-filled bags, tied at the top overnight in cold water. Remove and drain off the water and then dip in hot water at 55° C. for 5 minutes. Dip the bags in cold water to stop the action of the heat and then spread out to dry thoroughly, or sow the seeds. This method is effective for both external and internal seed-borne diseases.

Likewise, for internal seed diseases, the following method [1] is used, but this is only feasible on a small scale and is recommendable for experimental purposes. Soak the seeds in water overnight. Immerse for 2 to 5 minutes in 50 per cent alcohol containing 2 grams of mercuric chloride in each 1,000 cc. and shake. Use plugged, wide-mouthed bottles. Pour off the mercuric chloride solution and wash the seeds once with 93 per cent alcohol. Then wash them with clean or sterile water three times.

For spores adhering to the outside of the grain, the procedure to be followed is to soak seeds in clean water for six hours or

[1] After the method used for other cereals by C. C. Chen, Bulletin 240, Maryland Agricultural Experiment Station, 1920.

overnight. Drain off the water and then immerse in 1:1,000 mercuric chloride solution for 30 minutes. Then wash thoroughly with clean water three times. In disinfecting rice seeds, it is always advantageous to float and skim off all light grains first before proceeding in the use of any treatment. This will remove chaffy or infected grains as well as foreign materials, and will save any extra outlay for fungicides or for more seeds to the hectare due to decreased rate of germination and perhaps for re-sowing.

Chemical treatments by dusting or dipping are prescribed elsewhere under certain specific cases.

DISEASES OF MAJOR IMPORTANCE

SCLEROTIUM DISEASE

The sclerotium disease attacks both young and old rice plants. Blighting caused by this disease generally occurs in seedbeds. Sometimes it may also attack older plants where there is no standing water when a damp, hot weather obtains. In moist soil, under this weather condition, upland rice is also subject to its attack. It causes stunting and blighting of seedlings or yellowing of older plants in patches caused by a cosmopolitan soil-borne organism, *Sclerotium rolfsii* Sacc. White mats of tufted vegetative growth and white to brown sclerotial bodies or compact balls of fungous threads (resting stage of the fungus) may be seen on the ground, or attached to the base of the stem. These sclerotial bodies serve as a means of propagating the disease and perpetuating the species.

Control.—As soon as the disease is noticed in seedbeds, all plants, including the soil in the infested areas to a depth of six inches or more towards the belt of surrounding healthy plants, should be removed to prevent further damage. The irrigation water should be allowed to accumulate in the hole or excavated area. If water is plentiful, submerge temporarily all surface areas, but never allow it to pass through diseased areas. Thick planting or weedy culture is very conducive to the growth and progress of the disease and, therefore, it should be avoided. Cultivation, whenever possible, especially in upland rice culture, would check the progress and spread of the fungus.

It is not advisable to use for seedbed any place where the disease is known to have occurred in the previous season. In case no other land is available, which is unlikely to happen, chemical treatment of the soil may be used in severe infections as a last recourse. After the harvest, the land intended for seed-

bed should be plowed to break the continuity of the fungous threads and to admit plenty of aëration and sunlight. A month before sowing, the plowed-infested land should be crushed fine and then treated with bluestone solution (1 lb. copper sulphate to 7 gallons of water), or with 3 per cent commercial formalin at the rate of 2 liters of solution per square foot of soil.

HELMINTHOSPORIOSE

The helminthosporium disease, being seed-borne, is a frequent source of material damage to rice seedbeds causing blighting. When transplanted, the infected seedlings generally produce diseased plants and may spread rapidly to other plants or fields. The disease appears on the leaves as small, brown, oval or elliptical spots (plate 2), and as dark-brown elongated lesions oftentimes formed in bands around the stem at the seedling stage. On older plants (plate 3), the spots on the foliage are generally larger, semicircular or elliptical, with brownish or grayish centers and more definitely brown borders, and each spot has a yellow or orange zone around. They are visible on both surfaces and some run together, causing premature drying of the leaves. In the center of old spots, black felty masses of the causal organism are often visible. On the glumes (plate 4) and sheaths, it produces a brownish-black discoloration covered by velvety masses of black fungous growths. On or about the lowest joint of the rachis, and at the sheath-nodes, black velvety growths of the fungus may also be seen. The causal fungus is *Helminthosporium oryzae* van Breda de Haan. This disease attacks both upland and lowland rice, but it appears to be more injurious to the former than to the latter. It causes a reduction both in the quality and quantity of the produce.

Control.—For diseased seed, the control measure which is recommended is the hot-water treatment described elsewhere. This method is known to give satisfactory control, but sometimes secondary infection takes place. No chemical treatment has yet been found to completely rid seeds of vegetative parts of *Helminthosporium oryzae.* As the disease is seed-borne, selection of healthy seeds is very important. Only healthy seedlings should be transplanted. Clean culture is a necessary concomitant because the causal fungus has been reported to occur on a number of grasses. Sanitary measures will help greatly in reducing sources of infection in the field by burning all infected plants. Certain varieties like Dumali, Khao Bai Sri, Macan China, and Elonram, for examples, are very sus-

ceptible to the disease, while Elon-elon, Sipot, and Apostol are quite resistant varieties. Fertilization or liming of the soil would probably minimize greatly damage caused by this disease, it having been observed that the disease becomes more serious on weakened or partly starved plants, and less so on border plants.

BLAST

Rice blast and rotten-neck are synonymous. Blast is claimed by previous investigators abroad to be the most serious of rice diseases. Fortunately its known outbreaks in the Philippines have been quite sporadic, occurring at some intervals of time. Reports of initial outbreaks of the disease have been confirmed so far by the writer only in the provinces of Rizal, Laguna, Davao, Abra, and Nueva Ecija. Once a loss of about 25 per cent has been fairly estimated in a threatening outbreak in a comparatively newly opened land, but how the disease originated was largely a matter of conjecture.

The more usual manifestation of the disease in the Philippines is the rotten-neck, characterized by the elongated grayish or straw-colored lesion with a dark-brown border, produced around the neck region (plate 5) below the lowest node of the rachis or common axis of the head. As a result of this infection, there is shortening of the heads which are either partially filled or completely sterile. When, however, the infection takes place when the panicles are about to fill, they generally break over and, by the force of the wind or during harvest, some of them may fall off.

The leaf-spot form produced by the same disease may also be observed, but this seldom occurs. Young spots are uniformly water-soaked with yellowish borders, while older spots are quite irregular in size and shape, having a water-soaked, greenish-gray or ashen centers with dark reddish-brown borders. The old spots look somewhat like the eyespot of sugar cane.

The disease is caused by a virulent parasite, *Piricularia oryzae* Br. et Cav., which can be easily spread by the wind or introduced with the seed, especially that obtained from infested places or countries, particularly in the Orient. Its serious prevalence is greatly dependent on weather conditions, and upland rice seems to be more seriously affected by it than lowland rice. Buluhan, Inintiw, Mestiza, and Matungga are four susceptible varieties.

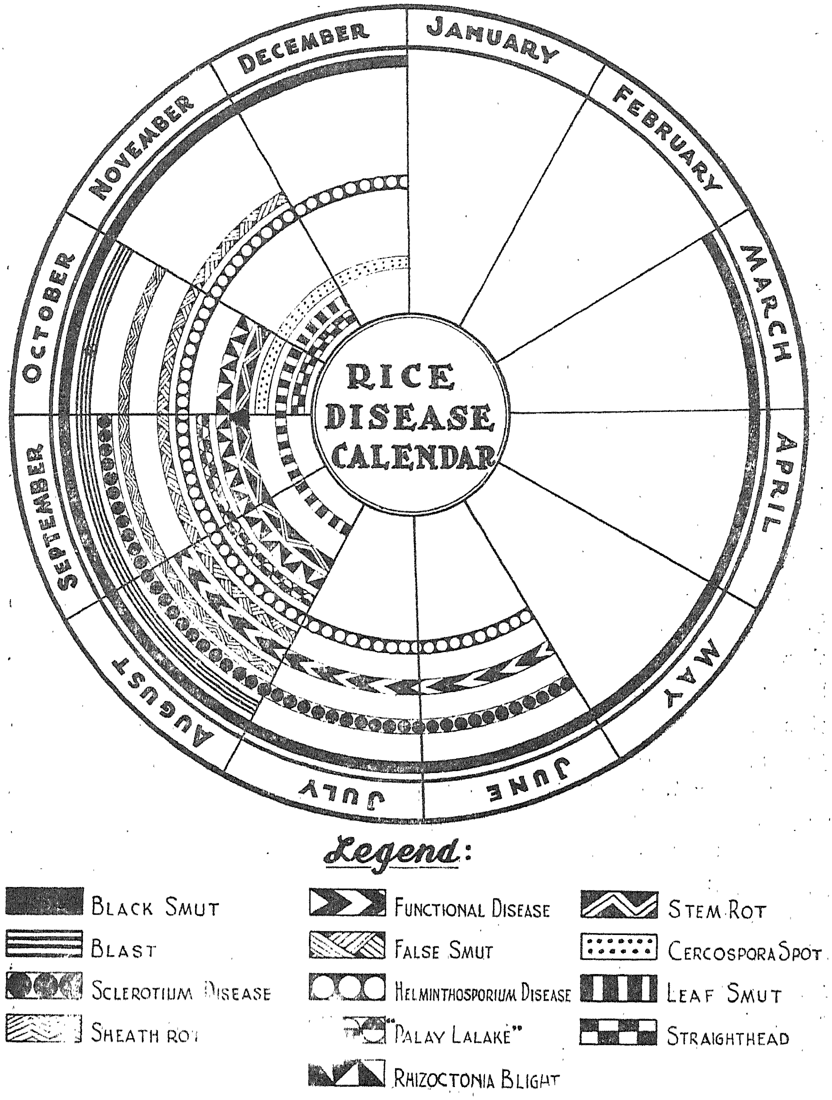


FIG. 1.

Control.—The most effective measure for the control of this disease is local quarantine, i. e., prohibition of seed distribution from infested areas. Complete destruction by burning of all sources of infection, such as the stubble, straw, husks, and eradication of weed hosts are also beneficial measures to take. On account of its liability to occur in epidemic form, the mechanical dissemination of the disease should be guarded against. The use of seeds from disease-free fields is advisable. In case of

persistent attacks, crop rotation may be employed as an extreme measure. Owing to the disastrous nature of this disease no efforts should be spared to stamp it out upon its inception in a locality or region. Field observations seem to indicate the possibility of discovering or developing varieties of rice possessing some resistance to blast.

"PALAY LALAKE"

This is a comparatively new disease which is fast gaining a foothold in some lowland rice districts and is, therefore, of increasing economic importance. It generally appears a month or so after transplanting. It is very conspicuous in the field by the narrow, light-green leaves and by the lanky growth of the affected plants, especially in fields where the plants are darker green than normal. In advanced stages a luxuriant growth of pinkish-white fungus, a species of *Fusarium,* may be seen accumulating externally on the stem above the water surface, especially at the nodal regions (plate 6).

Control.—The most important step towards its eradication is to rogue out the diseased plants as soon as noticed. Sanitation is equally an important adjunct, otherwise the foci of infection would be hard to eliminate. Its mechanical distribution should be guarded against. Burying of fresh infected plants, burning of the stubble, and the plowing of diseased fields after harvest should not be overlooked. These would rid the field of infectious materials inimical to the following rice crop. Plowing would hasten the drying of the fungus present in the soil.

Rice for seed should never be secured from diseased fields. Macan Bino, Apostol, Macan Biñan, and Guinangang strain 1 were found to possess some degree of resistance to the disease, while Macan 1, Macan Tago, Ramay (Ramai),[2] and Magcumpol are susceptible varieties.

STEM ROT

The stem rot is probably the most widely known of all rice diseases, causing at times damage of great proportions in some parts of the Philippines. Reports of its occurrence have been confirmed both in the Visayas and in Luzon under lowland conditions. It generally appears late in the season, attacking rice

[2] Studies on the morphological and physiological differences of the two varieties are in progress. Editor.

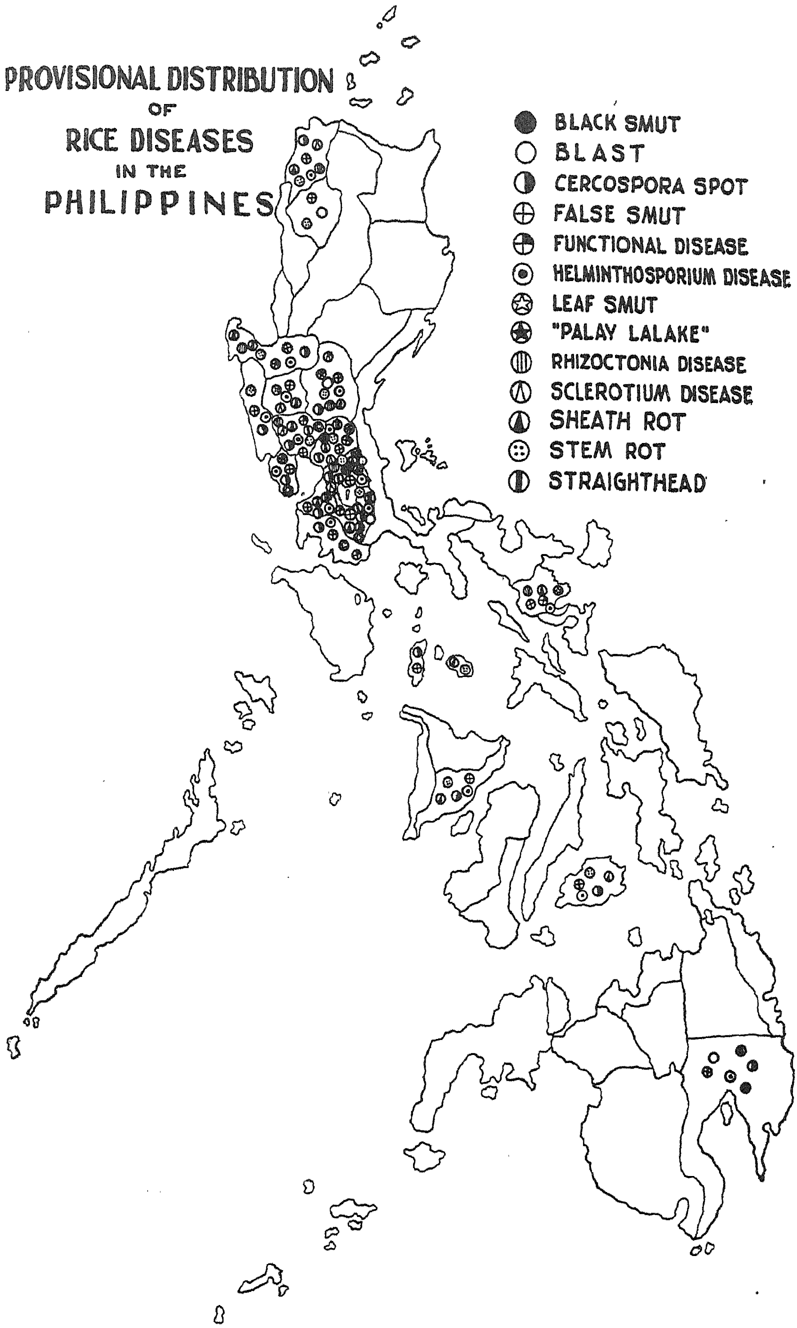

PROVISIONAL DISTRIBUTION
OF
RICE DISEASES
IN THE
PHILIPPINES
BLACK SMUT
BLAST
CERCOSPORA SPOT
FALSE SMUT
FUNCTIONAL DISEASE
HELMINTHOSPORIUM DISEASE
LEAF SMUT
"PALAY LALAKE"
RHIZOCTONIA DISEASE
SCLEROTIUM DISEASE
SHEATH ROT
STEM ROT
STRAIGHTHEAD

FIG. 2.

plants at the water level, causing brownish-black elongated lesions at the base of the stem, yellowing and then browning of the leaves, and finally a more or less complete decay of the stem tissues. As a consequence of severe infection, lodging may take place. When the disease attacks the plant at an earlier stage, partial or complete sterility of the panicles may result. Inside the diseased stem are lodged numerous spherical, shiny, black sclerotia and dense mats of ashen fungous threads (plate 7). The fungus responsible for this disease is *Leptosphaeria salvinii* Catt. (= *Sclerotium oryzae* Catt.).

Control.—The disease may be checked by draining the water from the newly infected fields for a few weeks or until the plants show signs of recovery before watering again. During the intervening time, however, the land must be kept just wet, and never allowed to crack up. Sanitary measures should be observed, such as the avoidance of scattering infected plants and soil. The irrigation water should not be allowed to flow from, or pass through, a diseased area to a disease-free one because the sclerotia of the fungus are capable of floating and may cause further damage upon contact with healthy plants. Burn all diseased stubble and straw *in situ* as soon as practicable so as to destroy the seats of infection and at the same time heat the surface soil. The substitution of resistant varieties, such as Elon-elon, Ramay (Ramai), Macan Biñan, and Raminad strain 3 for susceptible varieties is recommended in badly diseased localities, for it generally gives more lasting results.

SHEATH ROT

The sheath rot is another sclerotial disease of lowland rice. It causes yellowing and subsequent drying of the outer leaves through the infection of the leaf sheaths (plate 8) by the production of dark-brown lesions. Although the ravages of the disease are generally confined to the leaf sheaths of maturing plants, those attacked are very much weakened and as a consequence the yield is considerably reduced. Occasionally the causal fungus penetrates through the harder tissues of the stem. Close planting and stagnant water are conducive to the development of the disease, and readily lodged plants or varieties fall easy victim to it.

The causal organism is *Sclerotium sphaeroides* Nak., and the sclerotia, which are white when young and dark brown when old, are produced on (plate 8), or within, the sheaths, but seldom inside the culm. Masses of fungous threads may be seen also lodged in the cells of the sheaths and sometimes, but rarely, in

the hollow of the stem. The mature sclerotia have a somewhat rough surface and are irregularly shaped, simulating more closely the characteristics of *Sclerotium rolfsii* rather than those of *S. oryzae*. They are capable of floating and may develop on buoyant plant debris.

Control.—This disease is amenable to the control measures recommended for stem rot. Field observations seem to show that the strong-stemmed varieties like Macan Biñan, Kinatuday, Guinangang strain 1, and Ramay (Ramai) are less affected by the disease. The selection of resistant varieties apparently offers the best means of control.

RHIZOCTONIA BLIGHT

Rhizoctonia blight is caused by a fungus (*Rhizoctonia solani* Kühn.) that is common and attacks both seedling and maturing rice in low and poorly ventilated fields. It is an aggressive parasite under high temperature and moisture conditions. The attacked plants show irregular blotches of a variegated hue, with brown borders on the leaves and sheaths (plate 9). These characteristics are symptomatic of premature death. On these blotches, large, white to brown, irregularly shaped sclerotia may be seen adhering. Most of the affected plants remain erect and the grains fail to fill; some heads do not emerge at all, simulating very much a straighthead affection. Thick planting and nitrogenous fertilizers favor the development of the disease. Inadhica, Macan, and Sipot are susceptible varieties.

This fungus has also a variety of grass hosts, common neighbors, from which it passes to rice. The most common of these rice weeds are kolatay [*Cynodon dactylon* (Linn.) Pers.], muthá (*Cyperus rotundus* Linn.), bulang (*Panicum colonum* Linn.), and luyaluyáhan (*Panicum repens* Linn.). In addition to rice, it attacks other crops as well, such as wheat, corn, sugar cane, and soy bean.

Control.—Keeping the diseased field well watered for considerable periods would probably destroy the resting stage of the fungus and prevent its rapid spread. Thick planting should be avoided, especially in areas subject to the disease. Piling and burning of the plant trash to heat the surface soil, and plowing of the infested field after harvest are beneficial measures in eliminating as much as possible the sources of infection.

BLACK SMUT

The black smut, or bunt of rice (plate 10), caused by *Tilletia horrida* Tak. is a disease which is also carried by seeds. It is

systemic in character, affecting the plant from the time the seed germinates up to maturity. At the seedling stage, a few plants may show chlorosis. The affected plants when transplanted are somewhat retarded in growth. Under field conditions, the disease becomes noticeable only when the panicle matures by the presence of powdery black spores usually massed towards the tips of the grains, or by the eking out of the partially consumed kernel by the multiple spores produced inside. The bunted grains are usually lighter in weight and in color. In light-colored varieties, a blackish hue may be visible through the glumes of severely infected grains. Numerous spores produced on and inside the grain may be scattered by various agencies, and serve as potential sources of infection in subsequent crops. This disease causes not only a reduction in the yield, but may also depreciate the quality or lower the market value of rice.

Dry-season (or "palagad") rice culture seems to show more pronounced susceptibility than the regular rice-season culture, and early-maturing varieties show more susceptibility than the late-maturing ones. Sipot and Apostol are two of the most susceptible varieties, and to a lesser extent Guinangang strain 1, while Mancasar strain 3 and Elon-elon are considered resistant varieties.

Control.—The disease may be prevented by using seeds obtained from a healthy crop or from a locality where it does not occur. Care, however, must be taken in handling in order not to contaminate the healthy seed. For various reasons, local quarantine should be applied in infected localities to prevent the development of the disease in larger areas. Whenever possible it is always advantageous to grow the late-maturing resistant sorts in localities subject to black smut infection.

Seed treatment with hot water or with chemicals should be resorted to only where no sound seeds are available. Copper carbonate (56.68 grams of 50 per cent grade to 35.2 liters of rice seed) may be used, using a home-made revolving barrel duster. Soaking the seeds in twenty-five hundredth per cent solution of germisan (an organic mercury compound) for 30 minutes is another method of seed treatment for the black smut.

STRAIGHTHEAD

As the name indicates, plants affected with the disease show panicles that remain green longer than normal heads and stand erect and fail to set seeds (plate 11). The affected plants generally have leaves that are stiffer and darker green than usual,

and the sheaths are close. In rare instances, a chlorotic condition is manifested. Badly affected plants do not head at all, but simply remain sterile. Some show distortion in various ways, such as a shortening of the panicles or a decrease in the size of the grains. Magcumpol, Macan I, and Inadhica are commonly affected by this disease.

This diseased condition is caused by a variety of causes; by unfavorable conditions of environment, such as poor aëration of the soil and continuous submergence of the land. It may also be attributed to a certain fungal disturbance dealt with elsewhere, or to a mealy bug infestation.

Control.—Correcting the above conditions would prove to be beneficial because it would induce better development of roots and would restore normal nutritional activity. The damage caused by the insect should be dealt with differently in accordance with accepted principles not within the scope of this paper.

PHYSIOLOGICAL DISEASES

Diseases of functional or nonparasitic origin are caused by highly alkaline or highly acid soils, or by deficiencies of certain essential elements in the soil. Rice plants suffering from these causes are generally stunted and, while the presence of alkaline water or salt reaction (plate 12) shows stunting and a somewhat pale-green color or chlorotic condition of plants, those affected by acid reaction of the soil show severe retarded growth and yellowing. On the other hand, the lack of nitrogen in the soil, although it causes a general yellowing of the plants, does not hinder them so much in their growth as in the above-cited cases.

The presence of weeds in rice fields is intimately related with the normal nutritional activity of rice, for weeds, by crowding out rice, deprive it of some of its food in solution in the soil as well as moisture and sunlight. Their abundance, as noted in many places, has caused varying reductions in yield of grain and straw, frequently unaccounted for quantitatively.

Control.—Nitrogen starvation is amenable to soil amendments, while injuries arising from the first two cases seem rather remote of amelioration. Application of basic or nitrogenous fertilizers, however, may improve conditions. Soil areas traversed by highly alkaline water or by sulfur springs should not be cultivated to rice. Depending on the degree of acidity of a land, amount of rainfall, and soil structure, liming to restore normal reaction, or slight acidity, may improve conditions appropriate for rice culture. Highly sulfurated soil, however, devoted to this purpose, as found in Calamba, Laguna, should

better be abandoned in order to avoid crop failures and expense. Salt toleration among rice varieties may be developed in lands subject to salt water, as in Nagpili, Batangas Province.

The presence of weeds has also a close physiological relation in that it interferes with the normal growth and development of rice by occupying much space and by stealing food from the soil, which would otherwise be utilized by the rice plant. Weeds should, therefore, be eradicated, because they can materially reduce rice yields. Oftentimes they become sources of infectious diseases to rice and some may serve as intermediary hosts, especially the grasses. The best time to control weeds is before they flower or develop seeds.

MINOR DISEASES

There are several diseases affecting rice that are considered of lesser importance, among which are the green smut, the brown linear spot, the leaf smut, the bacterial leaf stripe, and the tip burn. Some of these are encountered regularly, while others appear only occasionally. However, only those that are of greater importance will be mentioned here.

FALSE SMUT

Although the false or green smut caused by *Ustilaginoidea virens* (Cke.) Tak. (plate 13) is a widespread disease of rice under lowland and upland conditions, it seldom becomes dangerous. Only individual grains are attacked in each panicle, the number ranging from one to sixteen, according to actual counts. Generally, however, one to five infected grains are commonly seen. They are green or orange-green powdery masses and very conspicuous by their size, being much larger than the grains, and may be seen on any part of the head. The lump of fungus projects between the glumes and presses them apart. The appearance of the disease is considered in some localities as an indication of a bumper crop, so practically no attention is paid to it by the farmers. Some varieties like Macan I, Apostol, Ramay (Ramai), Magcumpol and Inadhica are susceptible to this disease.

Control.—In case the disease becomes quite prevalent, which seldom happens, it is advisable to select healthy fields from which to secure seeds. Mechanical sieves, or the like, may be employed to get rid of the enlarged grains from the threshed rice to avoid any possible damage to the milled product. At the same time this step would minimize sources of infection in subsequent crops if no sound seeds are obtainable. The discarded swollen grains should then be burned or buried sufficiently deep

in unused ground. Seeds for planting purposes obtained from this batch may be steeped for 30 minutes in 1:1000 mercuric chloride solution, after having been presoaked in tap water for six hours or overnight and after draining off the surplus water. Then wash the seeds three times with clean water. The seeds may also be dipped in a solution made up of 1 pint (0.473 liter) of formaldehyde to 40 gallons of water (1 gallon = 3.785 liters) for 5 minutes. The treated seeds should then be sown immediately in wet soil.

BROWN LINEAR SPOT

This rice disease affects the leaf, sheath, peduncle, and glume, but it is more commonly considered a leaf spot disease because of the preponderance of the leaf lesions. The spots are brown and linear as the name implies and run lengthwise with the leaf (plate 14). The larger spots have light-brown or brownish-gray centers, and by coalescence they form much elongated lesions. Due to their number the operative leaf area of the maturing plant is very much reduced and this causes a weakening of the plant. Because of their great number, they also cause yellowing and hasten the drying of the leaves. The disease is caused by *Cercospora oryzae* Miy.

Control.—Varieties differ widely in their behavior to this disease. For example, it is very serious on Inadhica, but Ramay is less affected by it. The product of a cross between these two parent varieties [Ramay (Ramai) × Inadhica] yielded a highly resistant hybrid—Raminad strain 3. Mancasar strain 3 is another variety possessing considerable resistance, while Elon-elon and Khao Bai Sri are of moderate resistance. The other susceptible varieties are Arabon, Macan I, Magcumpol, Apostol, and Guinangang strain 1. Further observations would probably show a few other varieties not easily subject to its attack; these should be used to supplant the more easily injured varieties.

LEAF SMUT

Leaf smut is found on both lowland and upland varieties. This leaf affection is characterized by the black, small, rectangular spottings running parallel to the veins of the leaf (plate 15). They are slightly raised and visible on both surfaces. The presence of the disease lessens the manufacturing area of the leaf and is, therefore, detrimental to normal growth development. The causal fungus is *Entyloma oryzae* H. & P. Sydow.

Control.—The best method of controlling this disease appears to be the use of resistant varieties. Direct evidence, however, along this direction is still lacking.

ILLUSTRATIONS

PLATE 1
(Slightly enlarged)

Rice seeds severely infected with *Fusarium*, a seed-borne organism.

PLATE 2

Portions of stems and leaves of rice seedlings, showing numerous spots caused by *Helminthosporium oryzae*.

PLATE 3

Leaf spots of maturing rice caused by *Helminthosporium oryzae*.

PLATE 4

Rice heads showing severe infection by *Helminthosporium oryzae*. Note the number of affected, blackened grains.

PLATE 5

Rice panicles affected with rotten-neck (*Piricularia oryzae*). Note the characteristic lesions at the neck region pointed by arrows.

PLATE 6

Basal symptoms on a rice plant affected with "man rice" (a species of *Fusarium*).

PLATE 7

Stem rot of rice, *Leptosphaeria salvinii* (=*Sclerotium oryzae*), enlarged to show internal infection and presence of mycelial threads and numerous shiny, black, spherical sclerotia.

PLATE 8

A sheath-rot-affected rice stool caused by *Sclerotium sphaeroides*. Note the white and dark brown sclerotial bodies formed at the base of the stool.

PLATE 9

Portions of rice leaves and stems showing infection produced by the fungus, *Rhizoctonia solani*. Note the irregularly colored spots on the leaves and sheaths and the sclerotial bodies adhering thereon. Arrows indicate visible sheath lesions.

PLATE 10

Branches of rice heads infected with the black smut (*Tilletia horrida*). Note the ejected kernels (spur-like structures) caused by the multiplication of spores inside the glumes.

PLATE 11

Rice panicles exhibiting the characteristic straighthead affection.

PLATE 12

Rice seedbeds showing the injurious effect of salt water by the loss of normal green color, stunting, and eventual death of the seedlings.

PLATE 13

Two rice heads affected with the green smut (*Ustilaginoidea virens*), showing conspicuously the enlarged infected grains.

PLATE 14

Brown linear spot of rice caused by *Cercospora oryzae.*

PLATE 15

Leaf smut of rice (*Entyloma oryzae*). Note the black, rectangular spotting scattered all over.

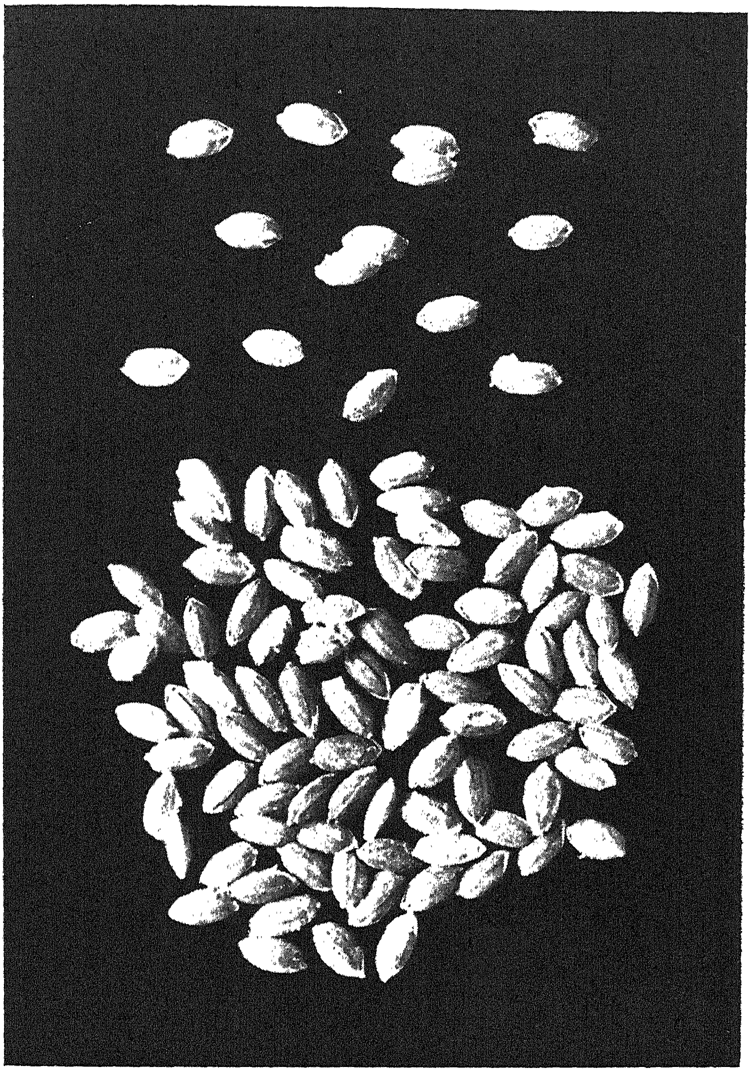


PLATE 1.

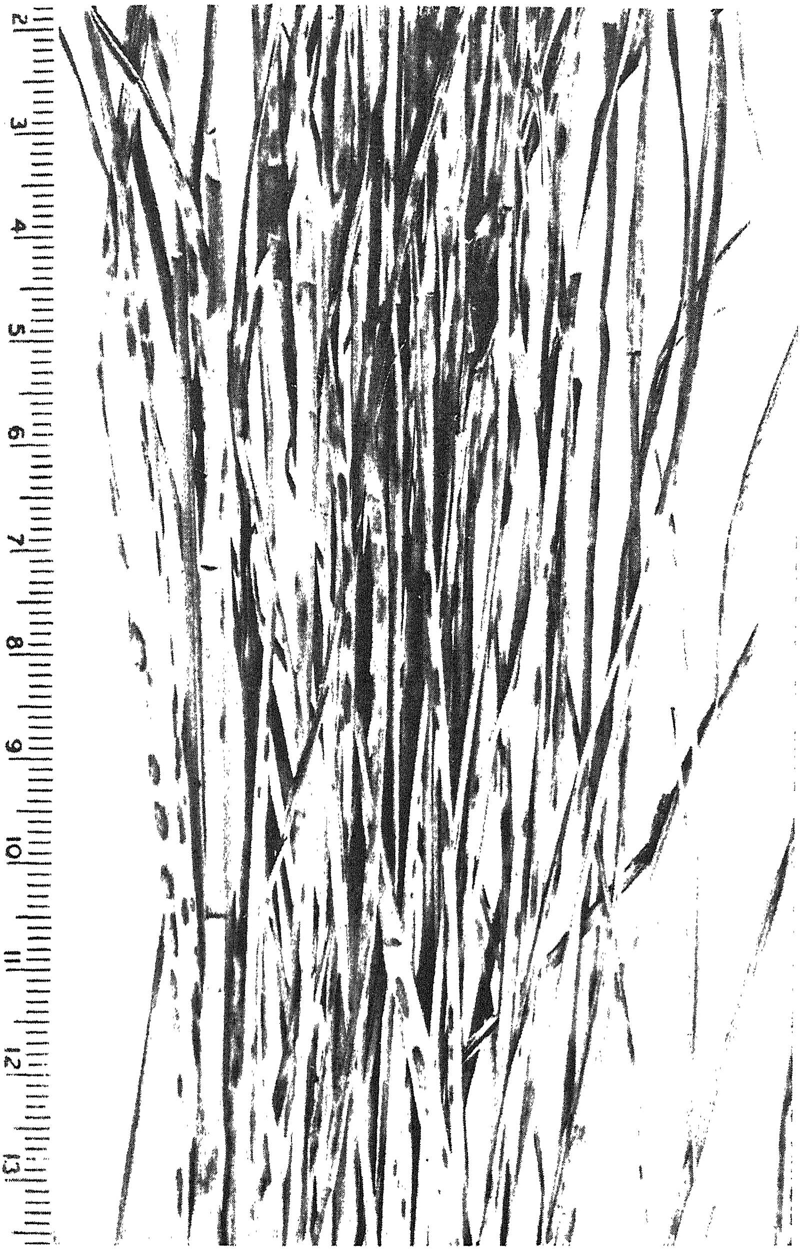
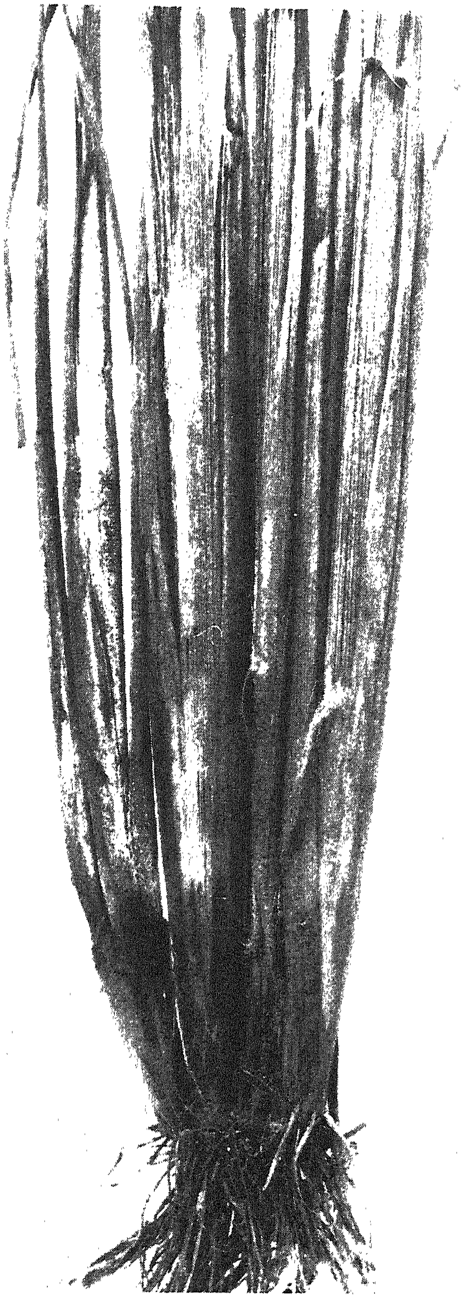


PLATE 2.

PLATE 3.

PLATE 4.

PLATE 5.



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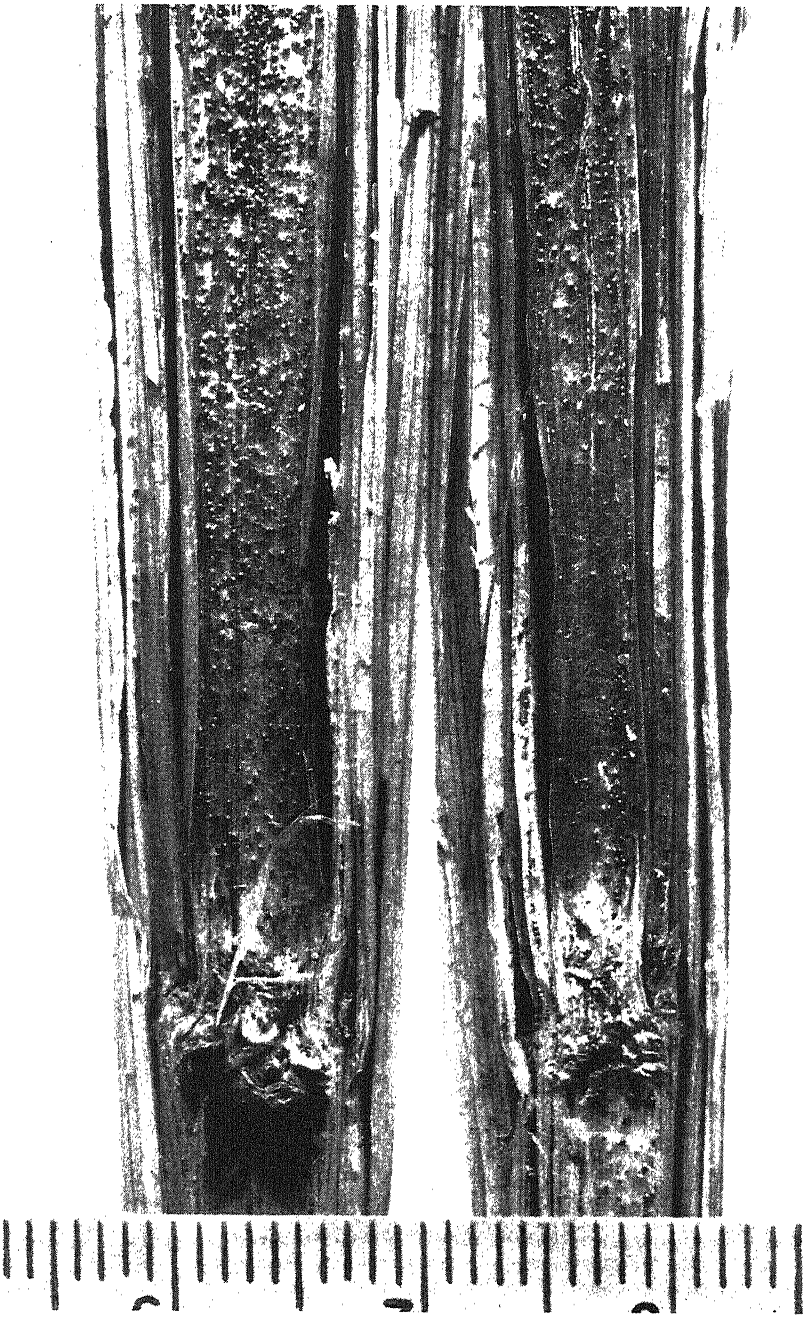

PLATE 7.

PLATE 8.

PLATE 9.

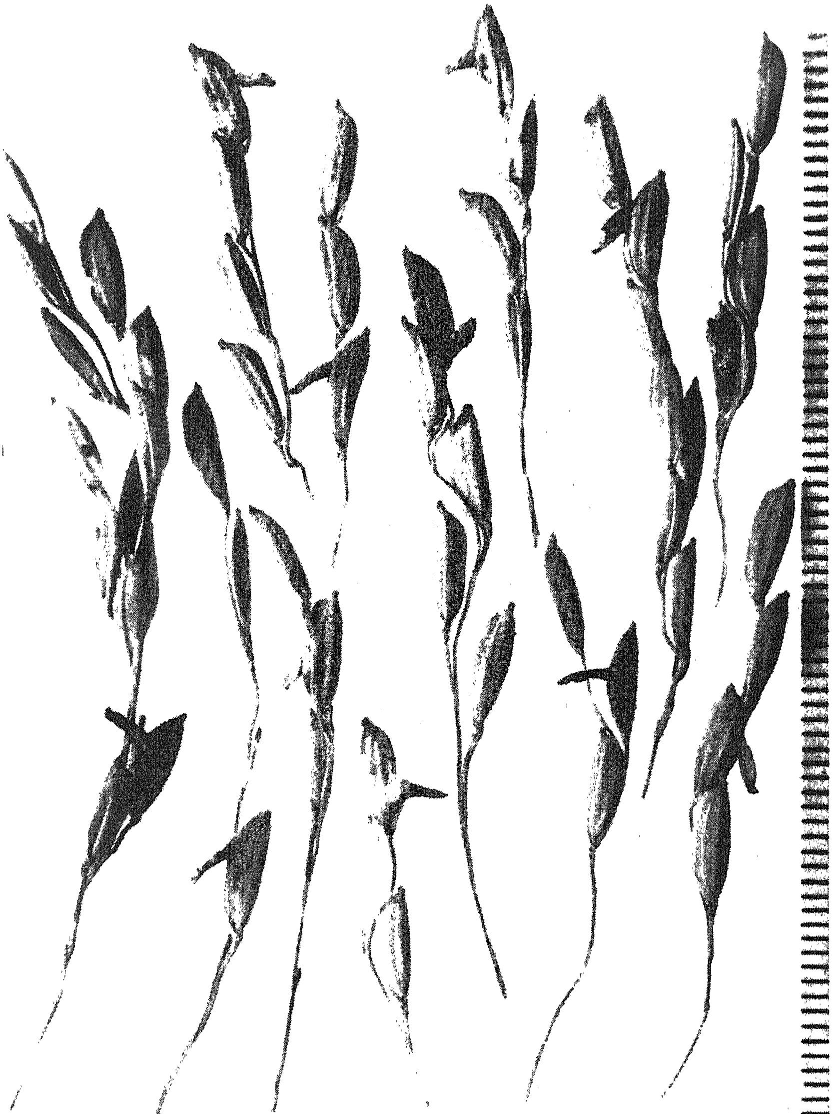

PLATE 10.

PLATE 11.

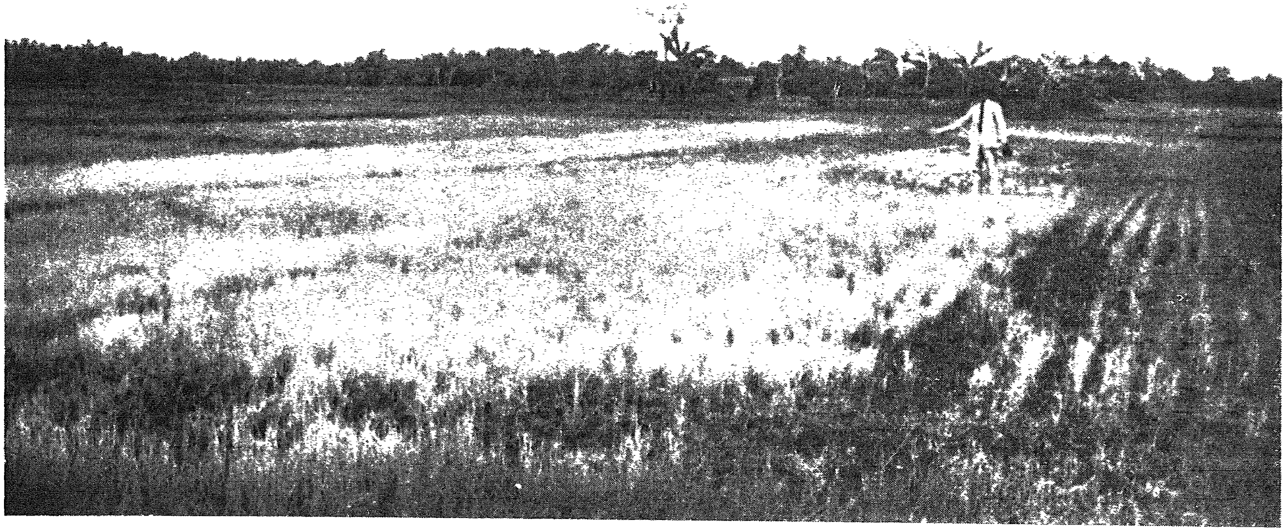

PLATE 12.

PLATE 13.

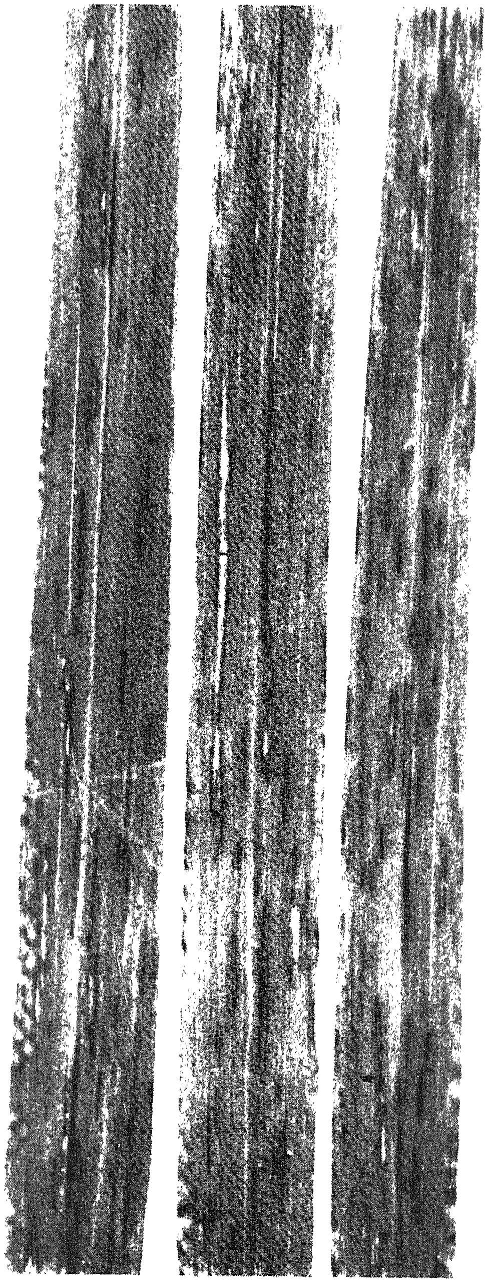

PLATE 14.

ERRATA

PROGRESS REPORT OF CABBAGE EXPERIMENTS AT BAGUIO, MOUNTAIN PROVINCE, by M. E. Gutierrez, Vol. 9, No. 1:

Pages 83 and 84, Table 1, Page 88, Table 2, Page 91, Table 3, Pages 95 and 96, Table 4, Page 101, Table 6,	Read ± instead of +, between the set of figures in every column opposite "Average per bed"

Page 101, Table 6, column 1, line 9. Read *65.276* instead of *65,276*.

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